John Willis
INSTRUCTOR

7970B MAGNETIC TAPE UNIT

DATAGATE®

HEWLETT hp PACKARD

7970B MAGNETIC TAPE UNIT

MAINTENANCE TRAINING MANUAL

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MAINTENANCE TRAINING MANUAL
(HP STOCK NO. 07970-90793)

TAPE Speed 37.5 INCH/SEC

DISCUSS TAPE/DISC MEDIA CARE
INDUSTRY COMPATABILITY

NOTICE

The information contained in this manual is for training purposes only. Consult the Hewlett-Packard documentation supplied with the system for current information.

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ABBREVIATIONS & MNEMONICS

Mnemonics	Definition
CF	Command Forward
CL	Off-Line Command
CR	Reverse Command
CRW	Rewind Command
CS0-CS3	Command Select 0 through 3
PCF	Programmed Command Forward
PCR	Programmed Command Reverse
RC	Read Clock
RD0-RD7	Read Data 0 through 7
RDP	Read Parity
SD2	200 BPI Status
SD5	556 BPI Status
SD8	800 BPI Status
SET	End of Tape Status
SFP	File Protect Status
SL	On-Line Status
SLP	Load Point Status
SR	Ready Status
SRW	Rewind Status
WC	Write Clock
WCD	Write Clock Delayed
WD0-WD7	Write Data 0 through 7
WDP	Write Parity
WE	Write Enable
WRS	Write Reset
WRSD	Write Reset Delayed
WSW	Set Write

TAPE BASICS

INDUSTRY COMPATIBILITY

- TAPE
- RECORD FORMAT
- RECORDING DENSITY
- METHOD OF RECORDING
- CHECK CHARACTER FORMAT

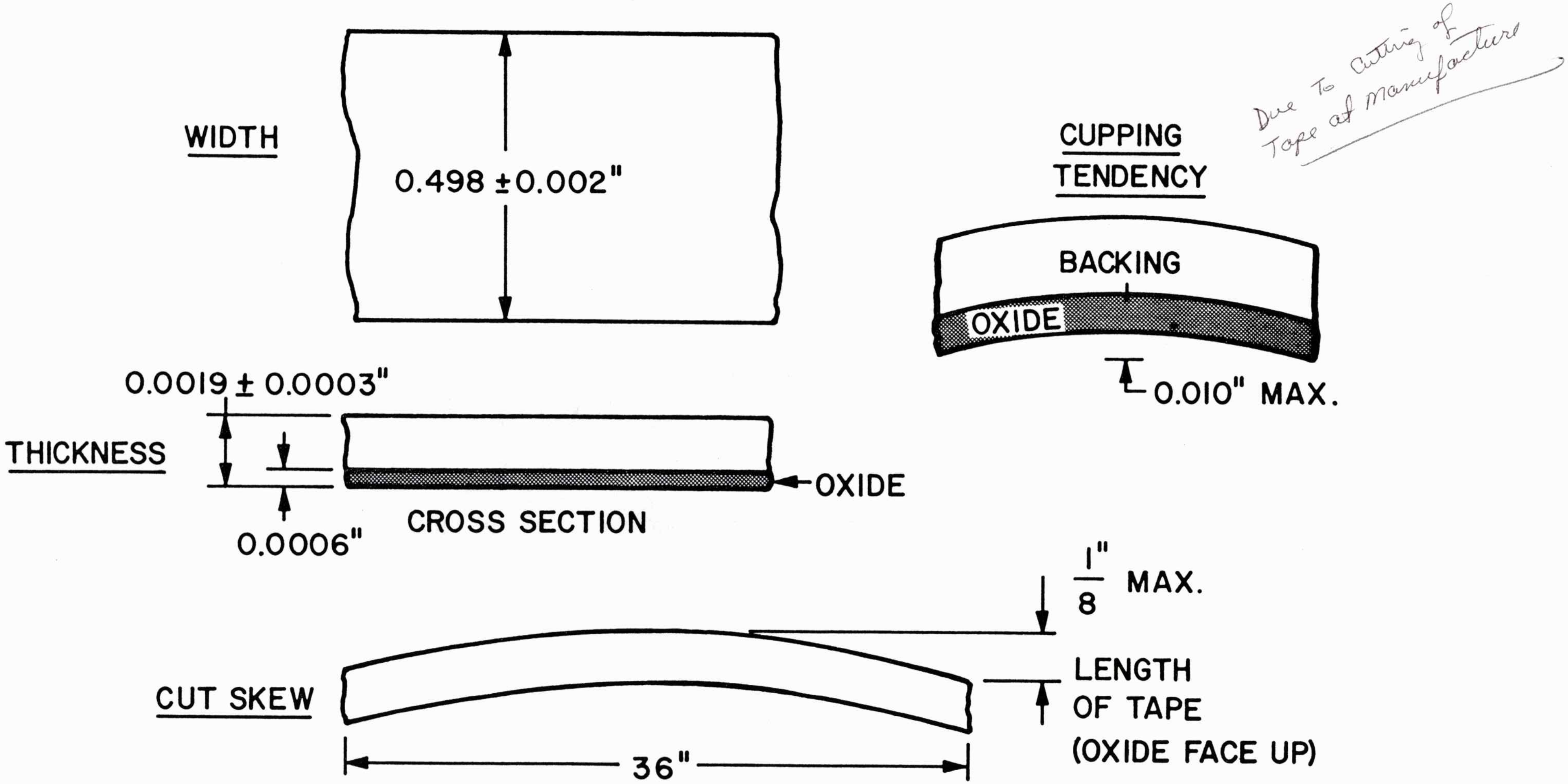
INDUSTRY COMPATIBILITY

If digital tapes are to be interchanged between tape units, standards of industry compatibility must be observed. Five basic requirements of compatibility are:

1. Physical dimensions and magnetic properties of the tape being used.
2. The format of the data records being stored on tape.
3. The density or characters per inch at which data is being recorded.
4. The method of magnetically representing data bits on tape.
5. The coding format of the data characters being stored on tape.

USA standards have provided guidelines covering all aspects of digital recording that must be observed if interchangeability is a product goal.

TAPE


WIDTH
0.498 ±0.002"
CUPPING TENDENCY
Due To cutting of Tape at manufacture
BACKING
OXIDE
0.010" MAX.
0.0019 ± 0.0003"
THICKNESS
OXIDE
CROSS SECTION
0.0006"
1/8" MAX.
CUT SKEW
LENGTH OF TAPE (OXIDE FACE UP)
36"

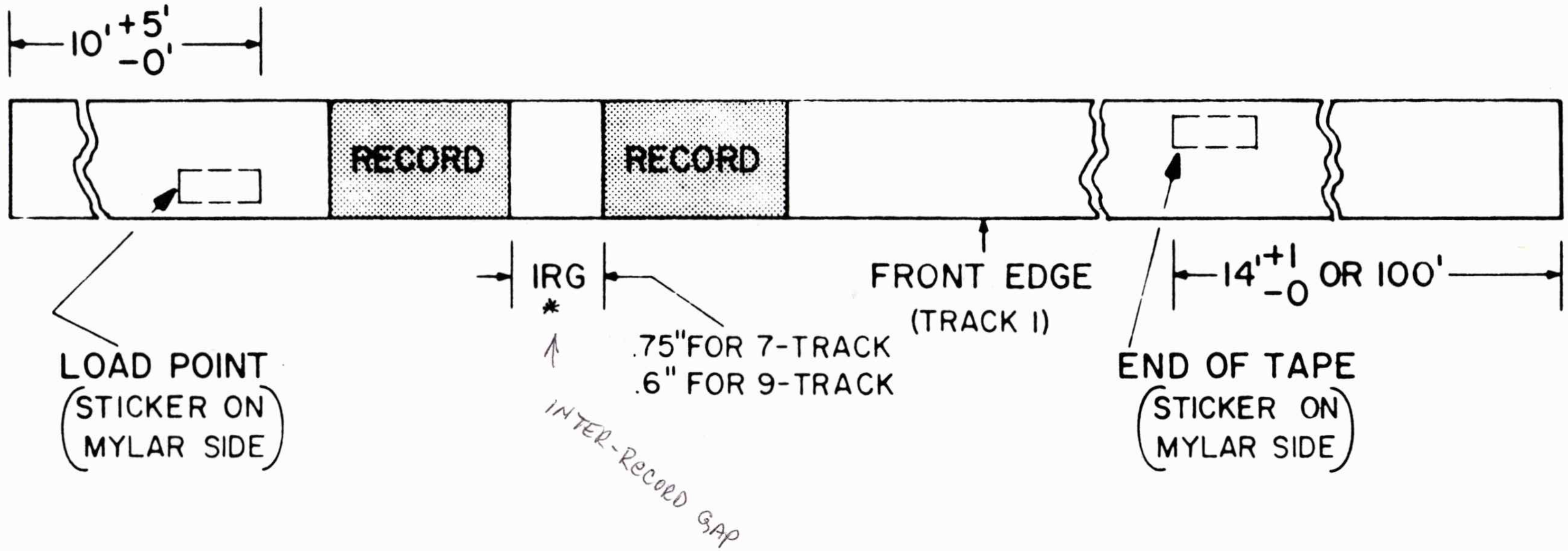
TAPE

A major consideration of magnetic recording is the physical dimensions and tolerances of the recording media. Digital tape is typically 1/2 inch wide and 2 mils thick. The thickness is the sum total of 1-1/2 mil mylar backing and 1/2 mil oxide coating which is used to magnetically store data.

Longitudinal variations or cut skew is related to the way the original mylar sheet is cut and handled during the manufacturing process. The cross-sectional cupping tendency is caused by the difference in the co-efficient of expansion between the mylar and oxide coating.

Design of a digital tape transport must take all physical characteristics of tape into consideration in order to pass it accurately over the head assembly.

TAPE FORMAT



D-073

TAPE FORMAT

Tape format is a consideration of industry compatibility. It establishes standards for placement of the load point (beginning of tape) and EOT (END OF TAPE) reflective tabs, first record placement and inter-record gap size.

The load point tab is placed on the reference (operator) edge of the mylar side of tape, approximately 20 feet from the physical beginning of tape. The first record begins no less than 1/2 inch from the trailing edge of the load point tab (IBM specifications). Record length is dependent on software. However, standards suggest record length be between 18 and 2048 characters. The inter-record gap (IRG) for a nine track system is nominally 0.6 inch and 0.75 inch for a seven track system. *

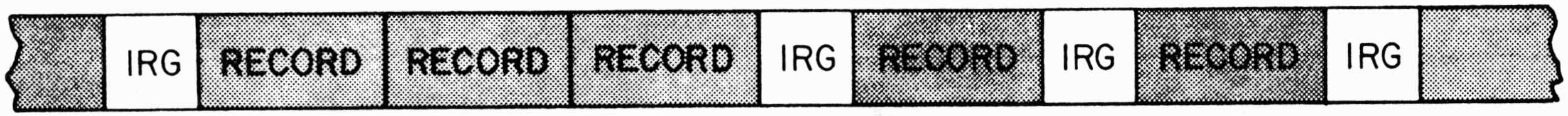
The end of tape reflective tab is placed on the transport (back) edge of the mylar side of tape, approximately 14 feet from the physical end of tape. This tab is used to signal the end of tape is near.

* The start stop time determines the IRG. (This is a tape unit feature)

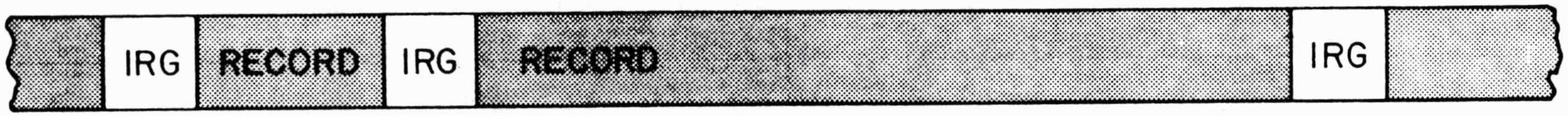
The interface determines the Record length.

RECORDS

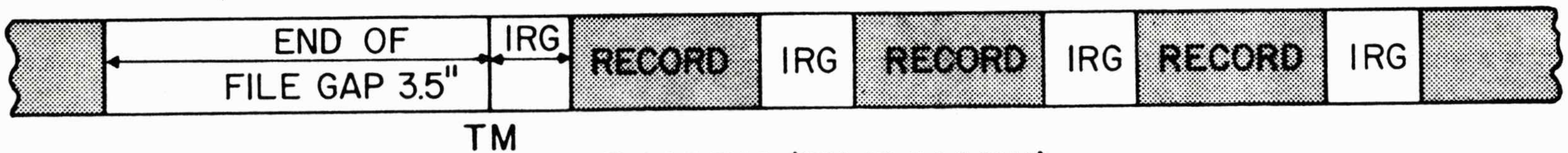
SINGLE RECORDS



BLOCKED RECORDS



VARIABLE LENGTH RECORDS



TAPE MARK (FILE MARK)
WITH A FILE GAP

RECORDS

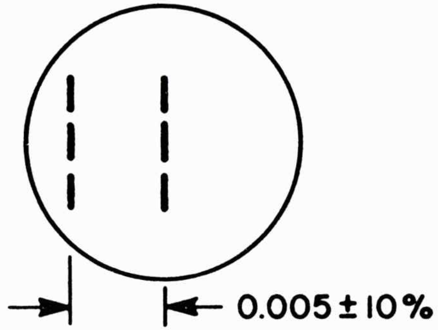
Recording format is defined by the programmer and the capabilities of the computer/controller. The single record format employs one logical record followed by an inter-record gap. These records may be either fixed or variable length.

Blocked records merge two or more logical records into one long block. Each individual record within the block is separated by a unique character.

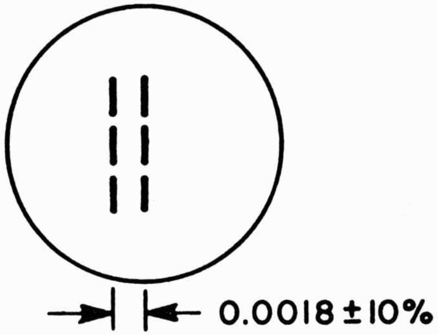
A tape mark (file mark) is a one character record used by software to indicate the logical end of a file or group of records. Its format consists of a single character followed by a check character called a longitudinal redundancy check character. The tape mark is normally preceded by a 3 to 4 inch gap of erased tape although the gap is not a requirement.

RECORDING DENSITY

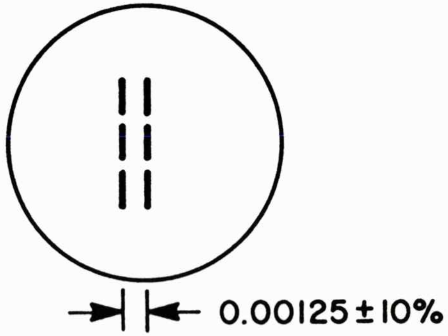
- 200 BPI



- 556 BPI



- 800 BPI



9 TRACKS

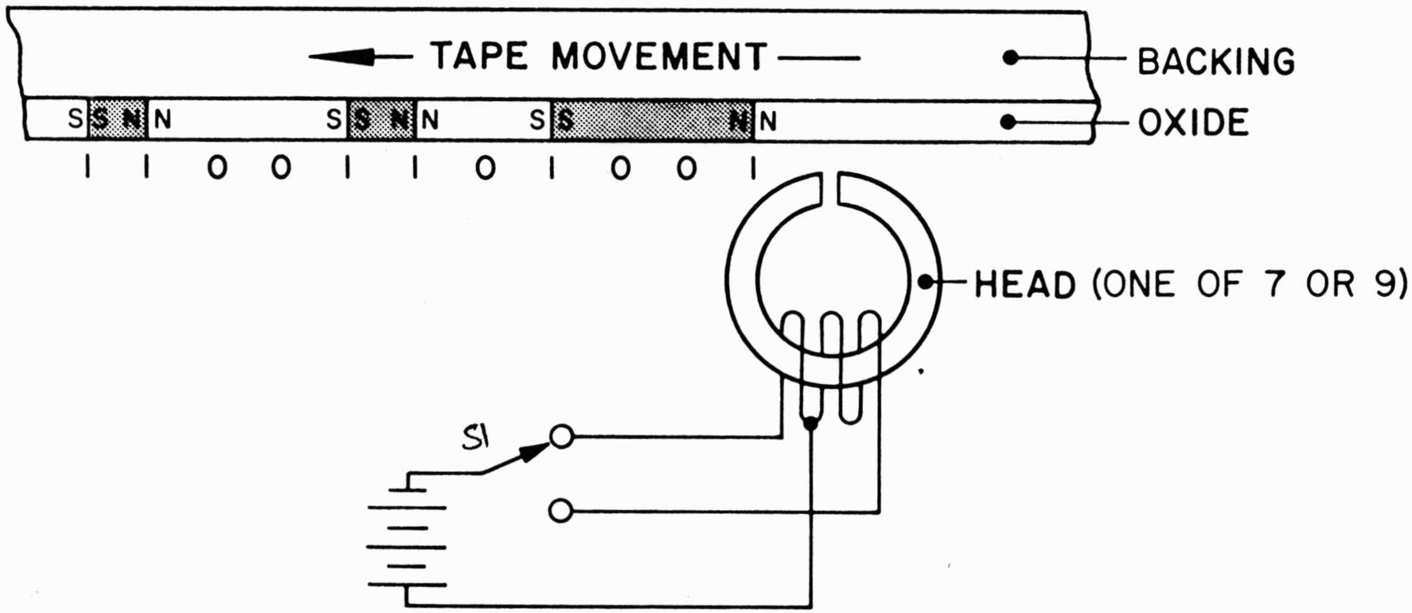
RECORDING DENSITY

There are three common industry standard bit densities for digital magnetic recordings. These densities are 200, 556 and 800 bits per inch (BPI) making bit to bit spacing from 0.005 to 0.00125 inches.

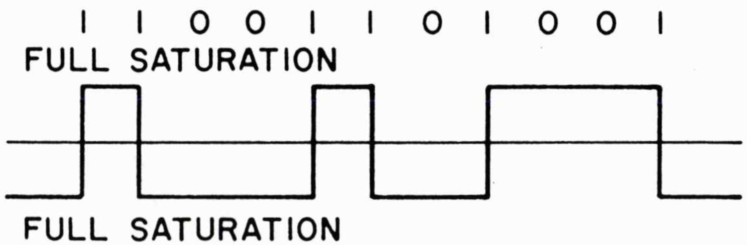
7970B Most nine track tapes are recorded 800 BPI while seven track tapes are recorded at 200, 556 or 800 BPI. The 7970A Magnetic Tape Unit is capable of reading or writing at all three densities.

Record density is determined by tape speed and rate at which data is clocked to unit.

NRZI RECORDING



OPERATION OF THE SWITCH.
ONLY A CHANGE FOR A LOGICAL "ONE" NO CHANGE IN FLUX FOR A LOGICAL "ZERO".



NRZI RECORDING

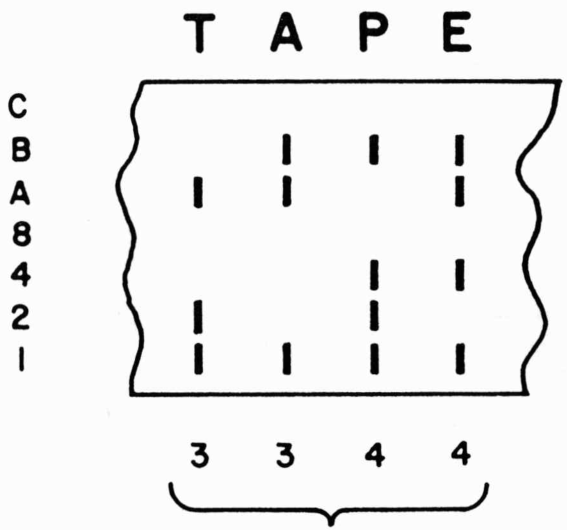
The method most used for recording digital magnetic tape is called **Non Return to Zero Invert (NRZI).** NRZI represents a logic one by inverting the magnetic saturation of the oxide.

As tape passes over the head assembly it first contacts the erase head which magnetically saturates it to the reset flux state.* After passing over the erase head it then contacts the write stack which saturates each track separately starting at the beginning of the record in the reset flux state. Each logical one in a track then inverts the magnetic saturation causing a concentration of flux at that point.

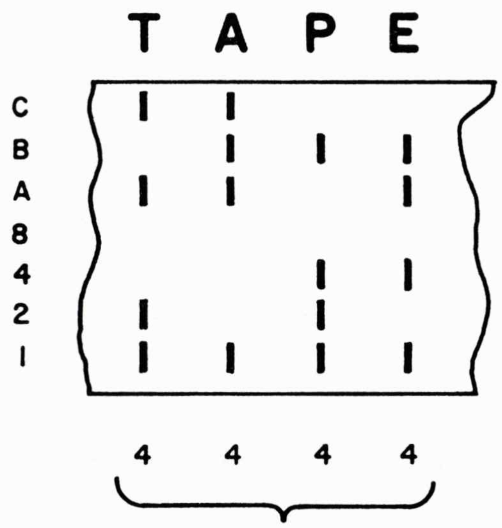
* Used for Reading. Page 1.15

*Reset flux state causes tape to be magnetized such that the beginning of tape is a north seeking pole.

LATERAL PARITY



LATERAL BIT COUNT
SOME EVEN, SOME ODD

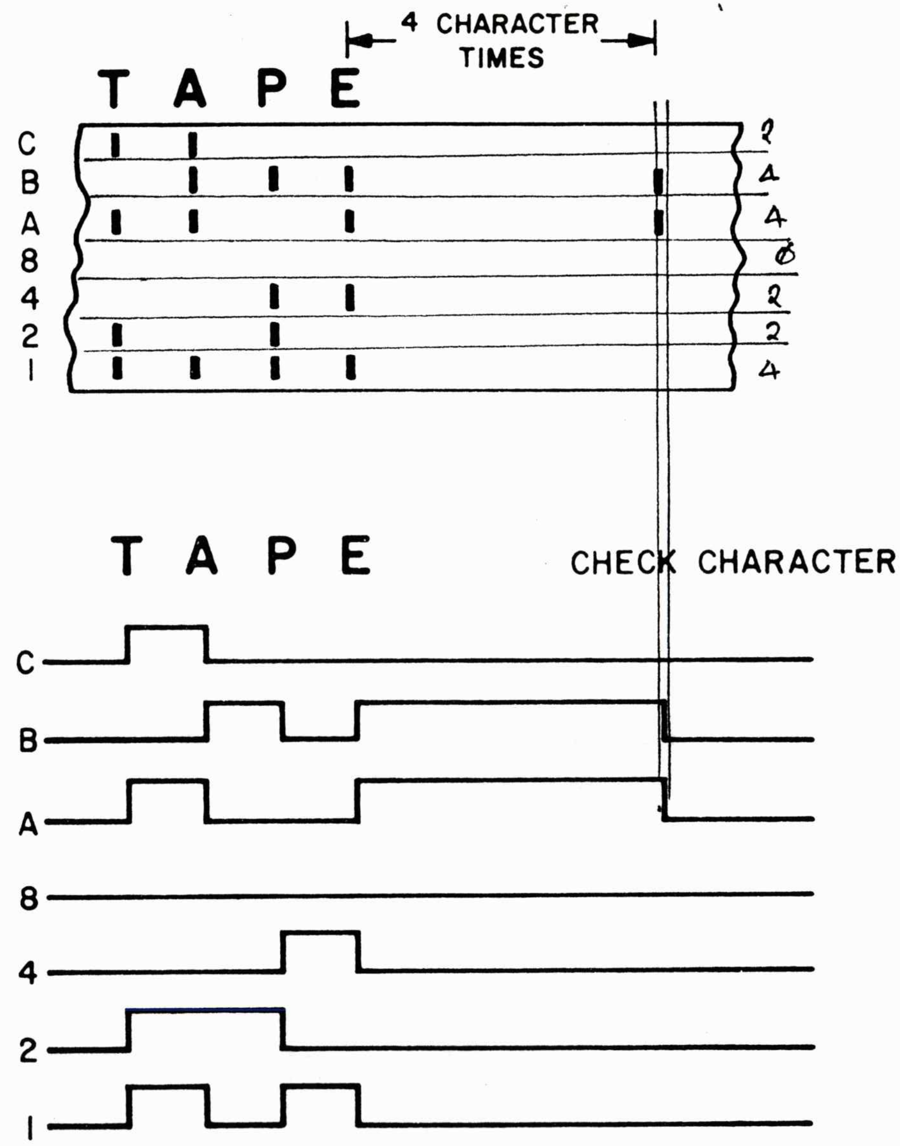


ALL EVEN BY
ADDING THE "C" BIT

LATERAL PARITY

Lateral (or vertical) parity checking is a method of detecting read or write errors. Seven track character format uses even or odd lateral parity depending on application. However, when using even parity 7 track format, each character including a data blank must be coded. A blank must be a coded character rather than a blank space on tape. Odd parity is typically used for scientific applications and even parity is used for commercial data processing applications. Nine track tape units always employ odd lateral parity.

LONGITUDINAL PARITY



ALL write heads returns to Reset state even parity.

see page 1.12

LONGITUDINAL PARITY

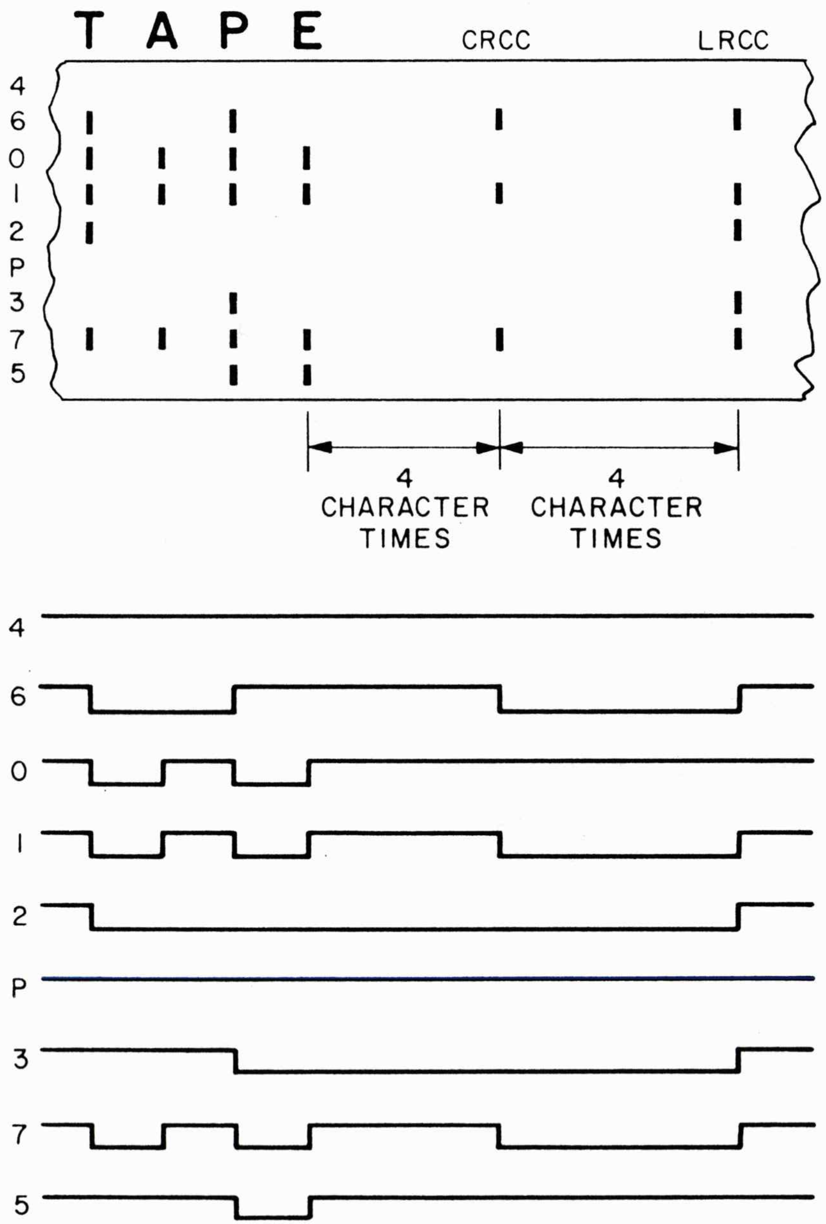
Longitudinal parity is maintained by the use of a LRCC (Longitudinal Redundancy Check Character). The LRCC is written on tape 4 character times after the last data character and maintains even longitudinal parity per track in each record. It is written by returning all write heads to the reset flux state.

Lateral parity is not maintained on the LRCC although the 9 track LRCC will always be odd parity. This is because of the formulation of a Cyclic Redundancy Check (CRC) character.

* All heads are in reset state before recording begins. Only head with an odd number of bits is written will be reset.

* For 9 track it is 4 characters after CRCC

9 TRACK ERROR CHECK



CRCC REGISTRATION

INPUT REGISTER	OE	CRCR POSITION	OE	CRCR POSITION	CRCR CHANGED
P	OE	7			P
Ø	OE	P			Ø
1	OE	Ø			1
2	OE	1	OE	7	2
3	OE	2	OE	7	3
4	OE	3	OE	7	4
5	OE	4	OE	7	5
6	OE	5			6
7	OE	6			7

exclusive 'OR'

NINE TRACK ERROR CHECKING

Nine track tape units employ odd lateral parity checking, longitudinal parity checking and cyclic redundancy checking. The Cyclic Redundancy Check Character (CRCC) is a one character representation of all bytes in a data record. It is developed by exclusive ORing, each byte with a shifted CRC register. The result is a character that somewhat represents a diagonal parity check character which is written 4 character times after the last data byte. The LRCC is then written 4 character times after the CRCC.

Channel scrambling is performed in the 7970 to maintain industry compatibility. The purpose of channel scrambling is to place the most used channels on the center of tape, which decreases the possiblity of tape error.

REASONS FOR TAPE FAILURE

- DROPOUTS
- SELF CONTAMINATION
- LOW WRAPPING TENSION
- HIGH WRAPPING TENSION
- EDGE DAMAGE
- POOR ENVIRONMENT

REASONS FOR TAPE FAILURE

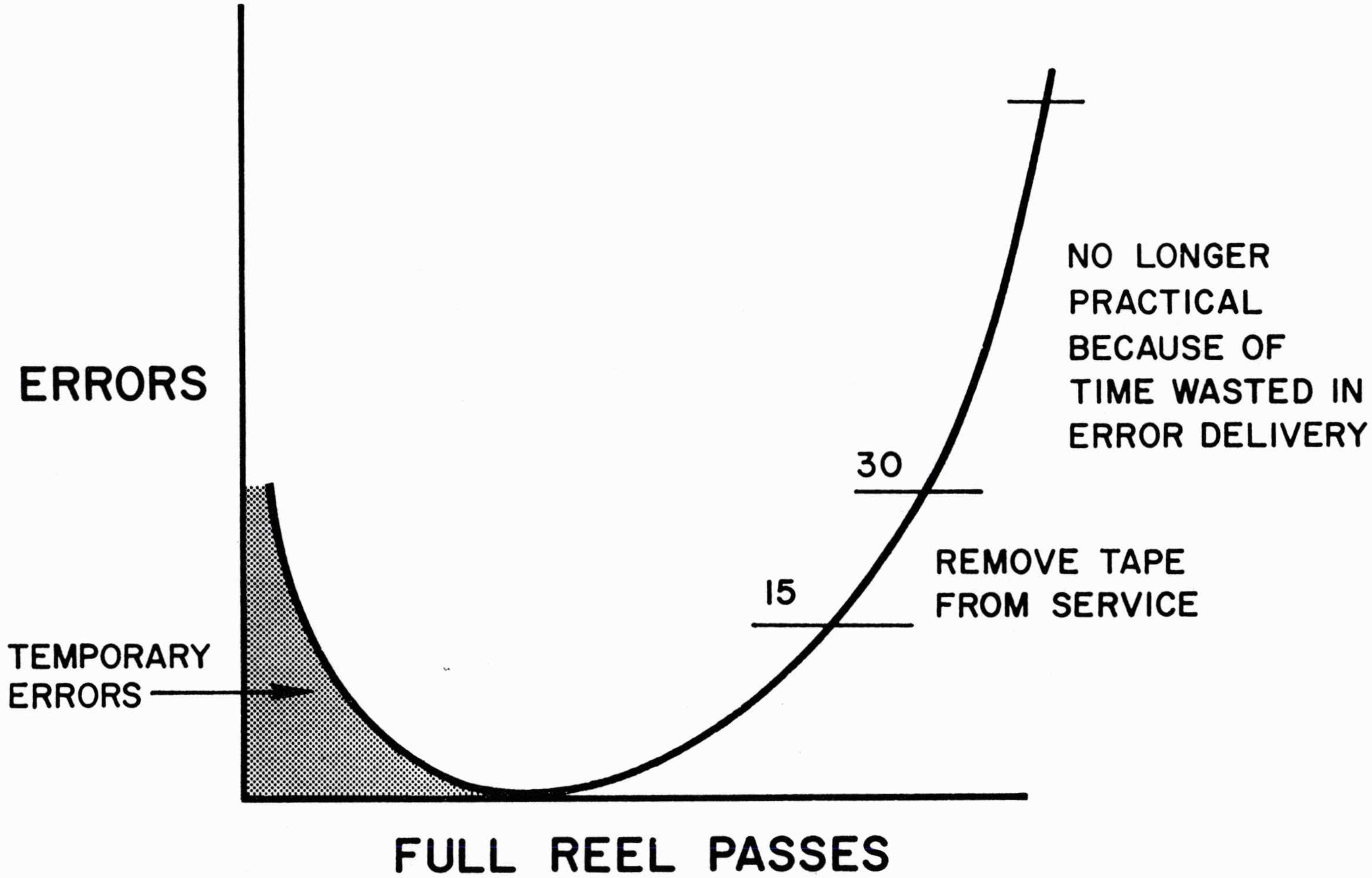
Tape failure may be caused by problems other than tape unit or electronic errors. Not meeting the critical physical requirements of tape or tape handling may be the cause of some tape errors. A minute section of tape, for instance, may loose its oxide coating. This dropout will cause the magnitude of the output to decrease significantly and may produce a tape error. The particle of oxide lost may be re-deposited elsewhere on the tape causing self contamination. This self contamination may cause the tape to lift when passed over the head due to the double thickness of oxide, causing a second error.

Wrapping tension around the capstan and head assembly is also critical. Excessive tension may cause the tape to stretch or "take a set" if left in one position too long. This in turn alters the dimensions of tape causing instability as it is guided over the head. Low wrapping tension may allow the tape to lift off the head or allow tape to slip on the capstan.

Edge damage may be caused by improper tape storage, poor operator handling or scraping the edge of tape on some object in the transport. This damage may alter the tape width and allow it to "snake" over the head causing excessive dynamic skew.

A poor or unclean environment may decrease tape efficiency. Digital magnetic tape is susceptible to tape errors caused by minute particles of dirt. Poor atmosphere, unclean transport and not properly storing tapes are a few ways tape can become contaminated and unfit for use.

MAGNETIC TAPE PERFORMANCE

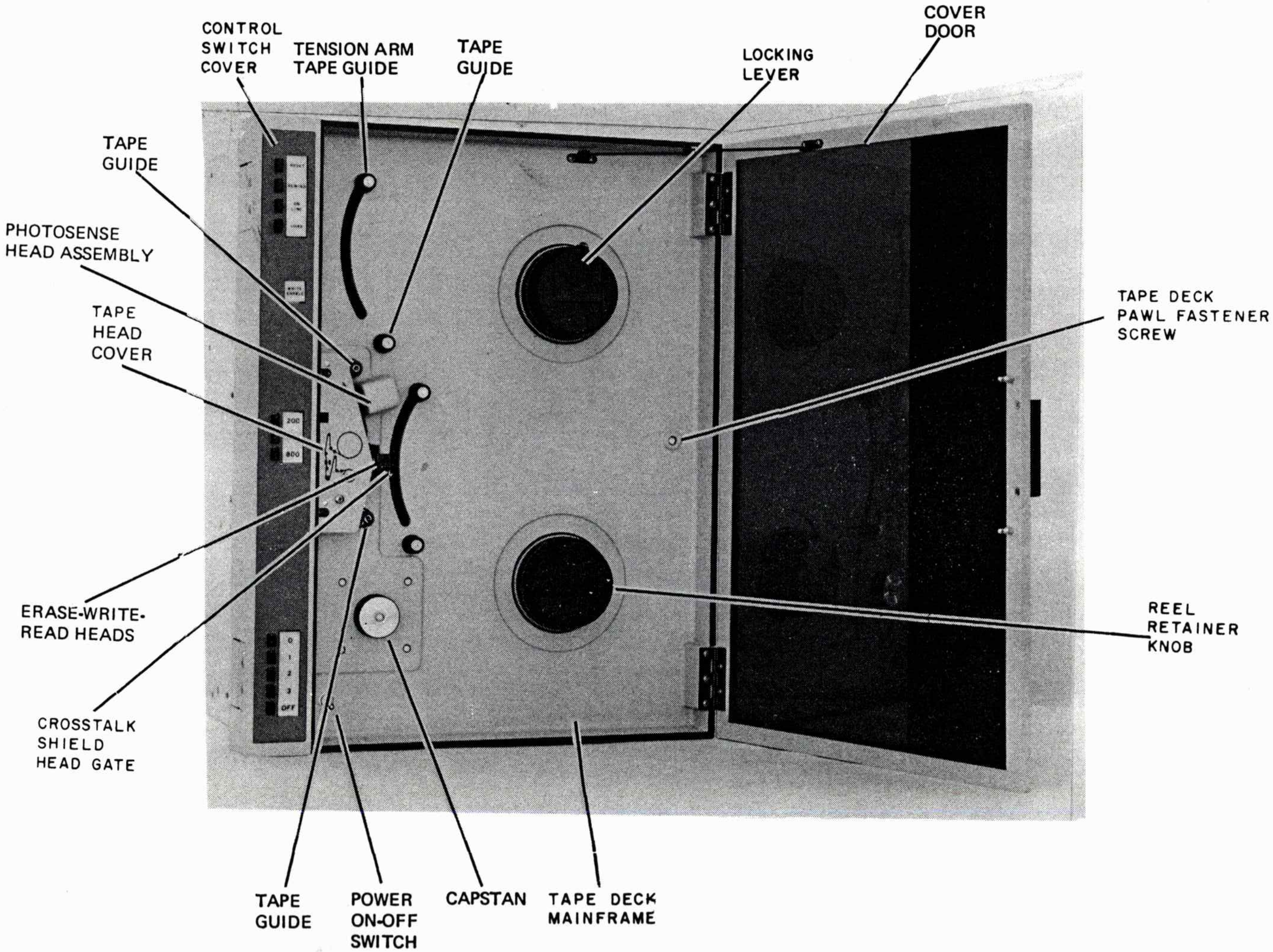


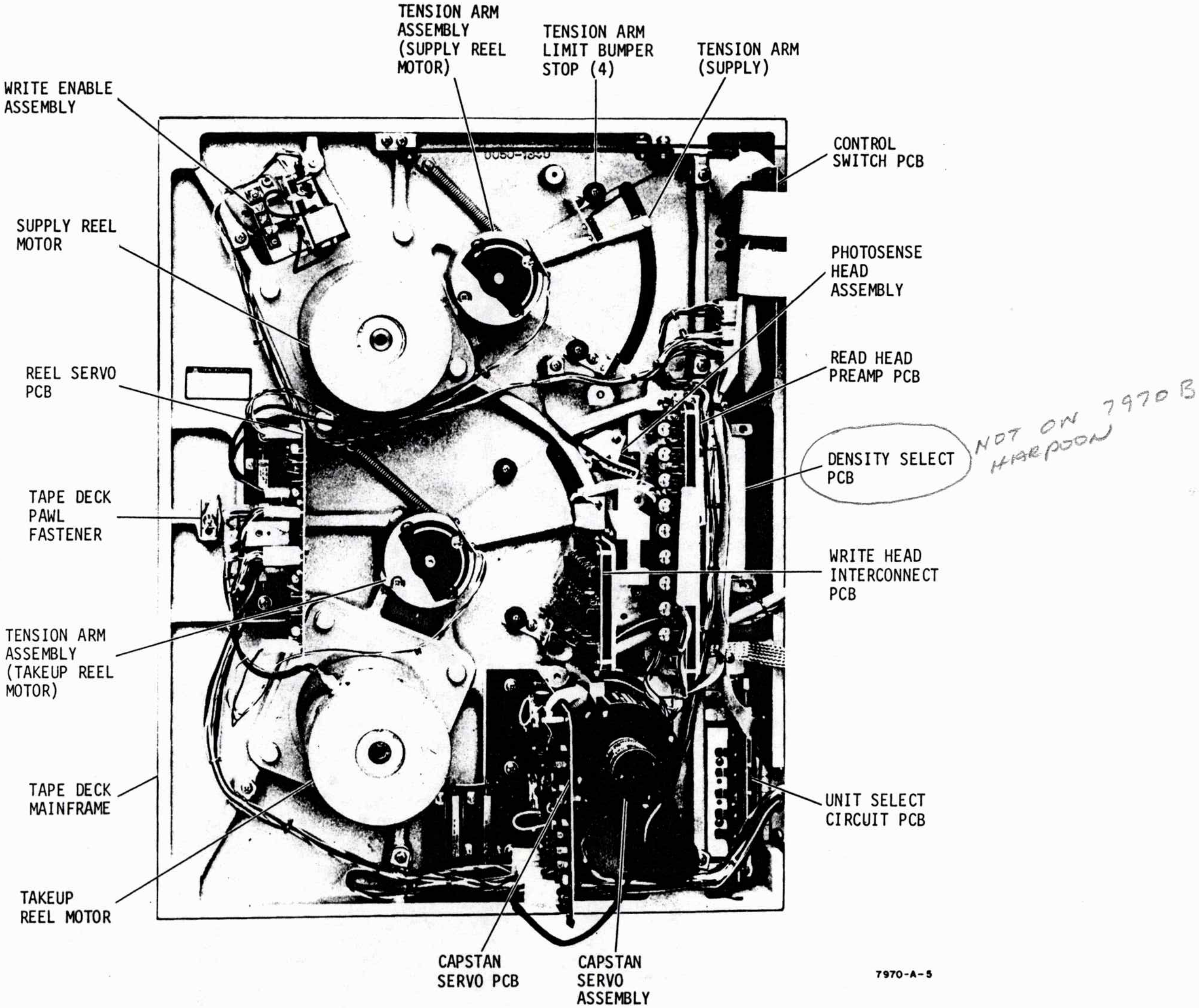
MAGNETIC TAPE PERFORMANCE

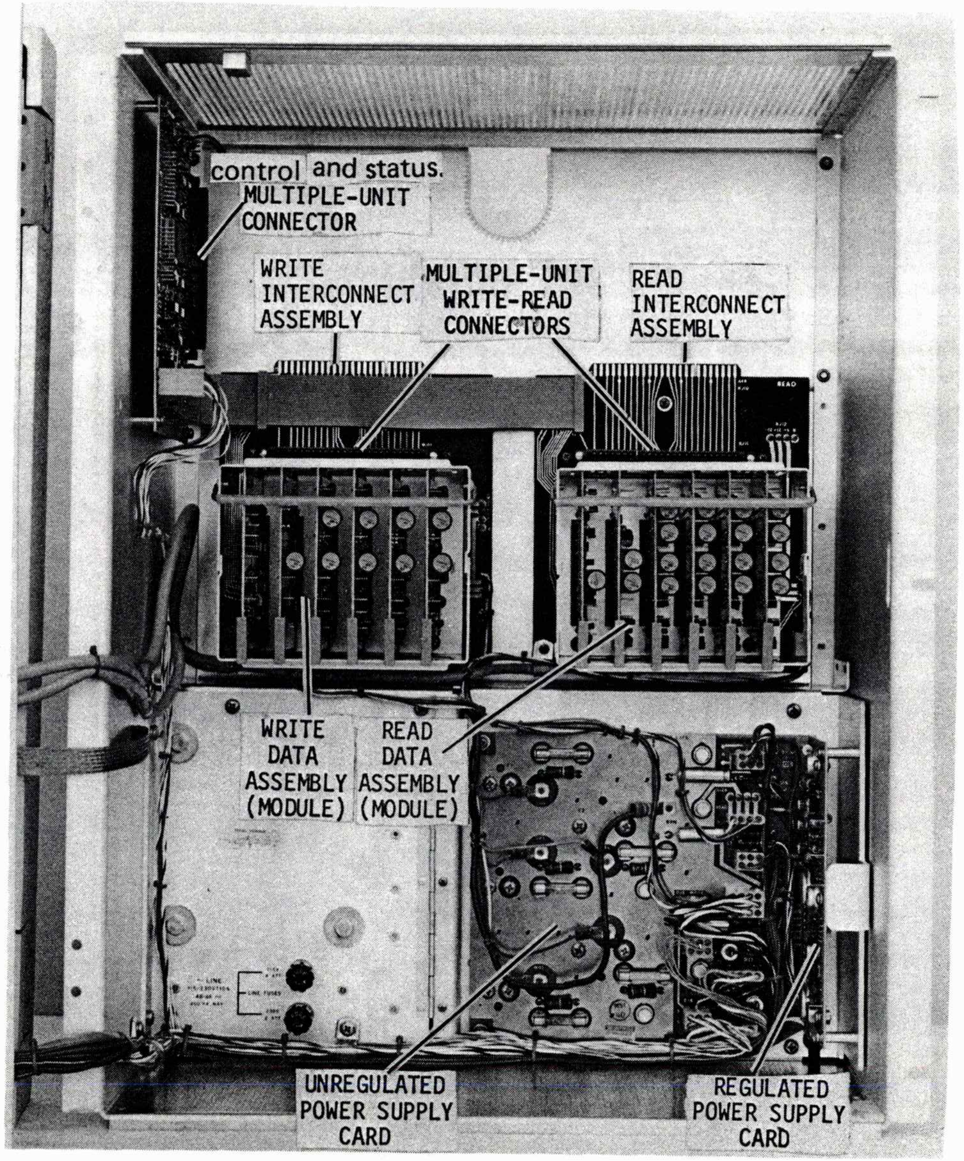
A new reel of magnetic tape may exhibit a number of temporary errors due to dirt or imperfections in the oxide coating. Passing the tape over a tape cleaner or head a few times cleans or polishes the tape and achieves optimum performance.

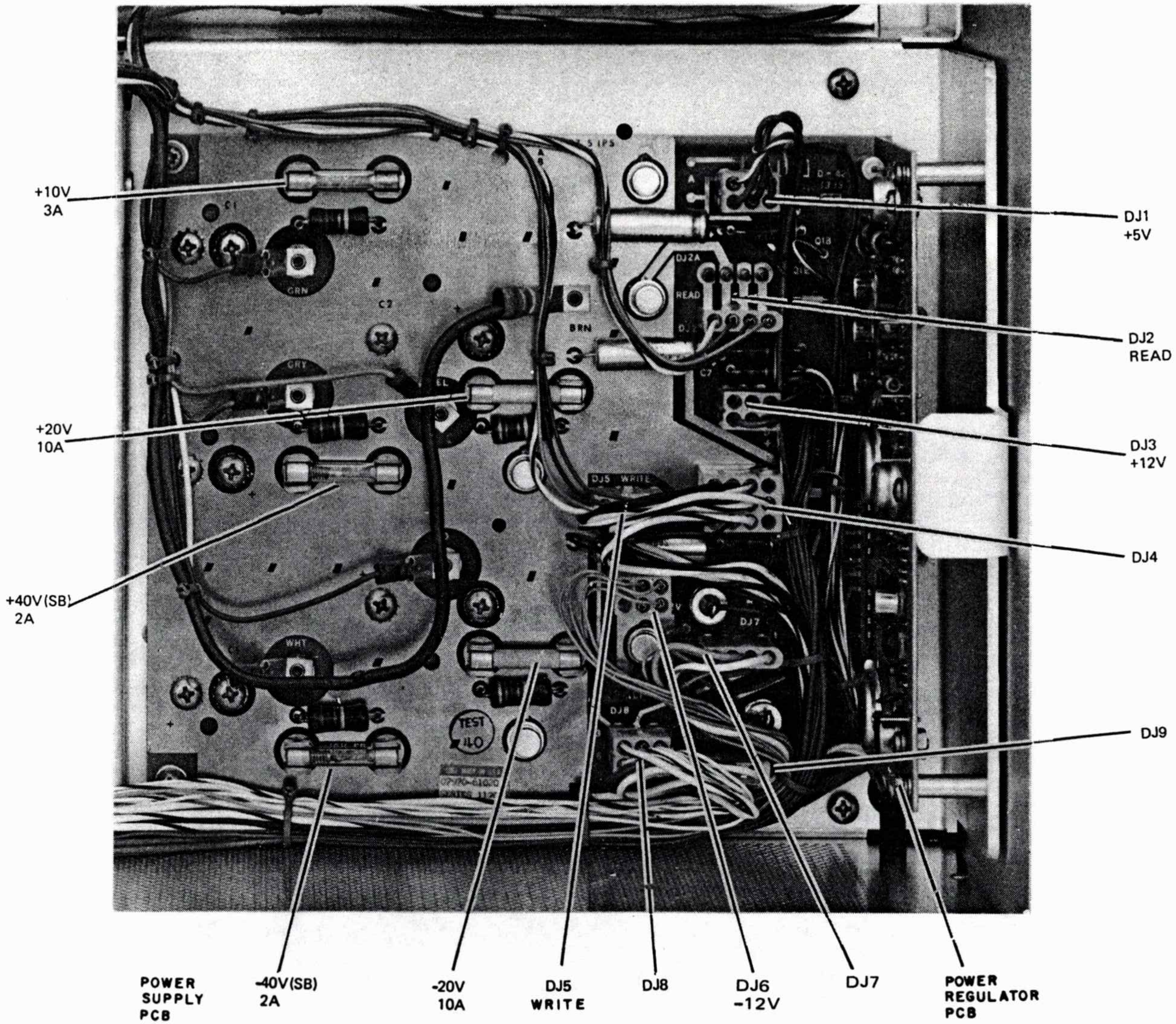
After some number of passes over the head, a tape may begin to exhibit an excessive number of errors. When a user experiences some number of errors (typically 15 to 30), the tape is no longer economical for use. At this time the tape is removed from service to be cleaned and verified. If this is not successful, the front or used portion of tape must be removed and a new load point tab installed.

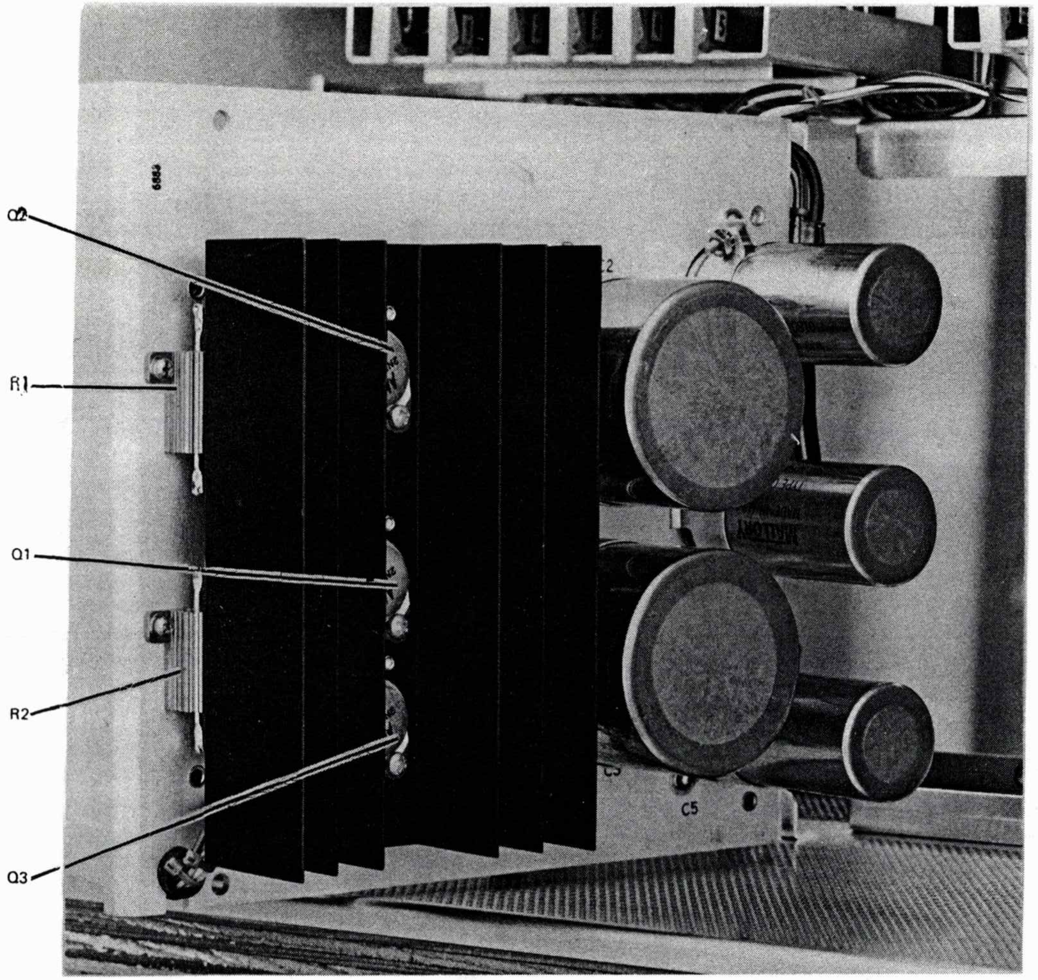
TRANSPORT

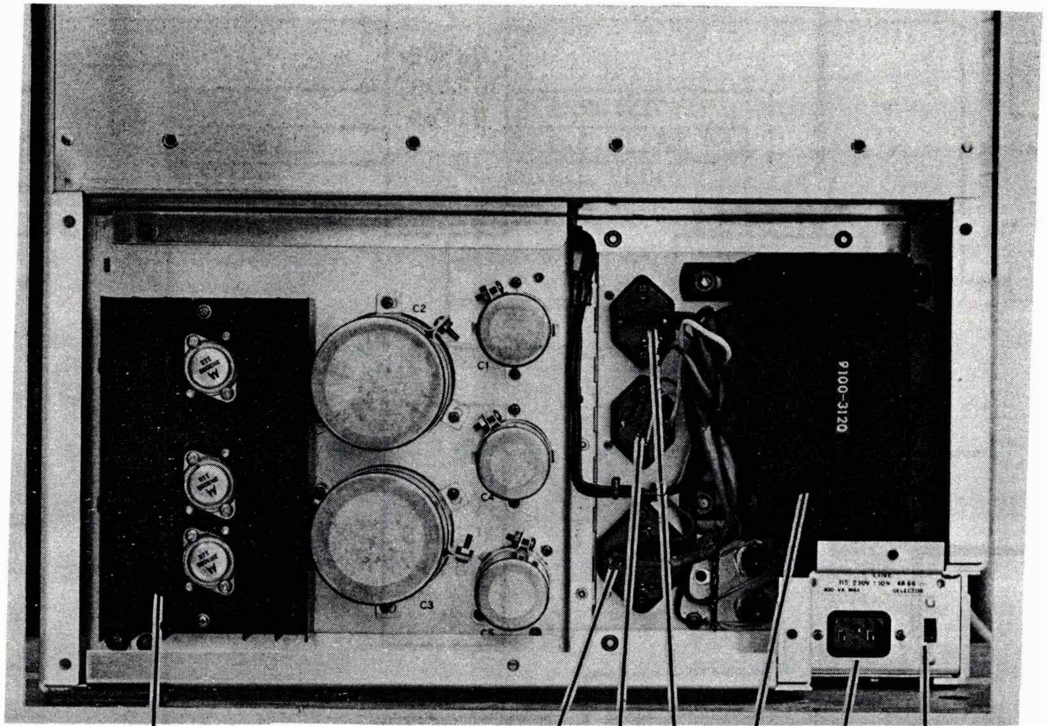

CONTROL SWITCH COVER
TENSION ARM TAPE GUIDE
TAPE GUIDE
LOCKING LEVER
COVER DOOR
TAPE GUIDE
PHOTOSENSE HEAD ASSEMBLY
TAPE HEAD COVER
TAPE DECK PAWL FASTENER SCREW
ERASE-WRITE-READ HEADS
REEL RETAINER KNOB
CROSSTALK SHIELD HEAD GATE
TAPE GUIDE
POWER ON-OFF SWITCH
CAPSTAN
TAPE DECK MAINFRAME

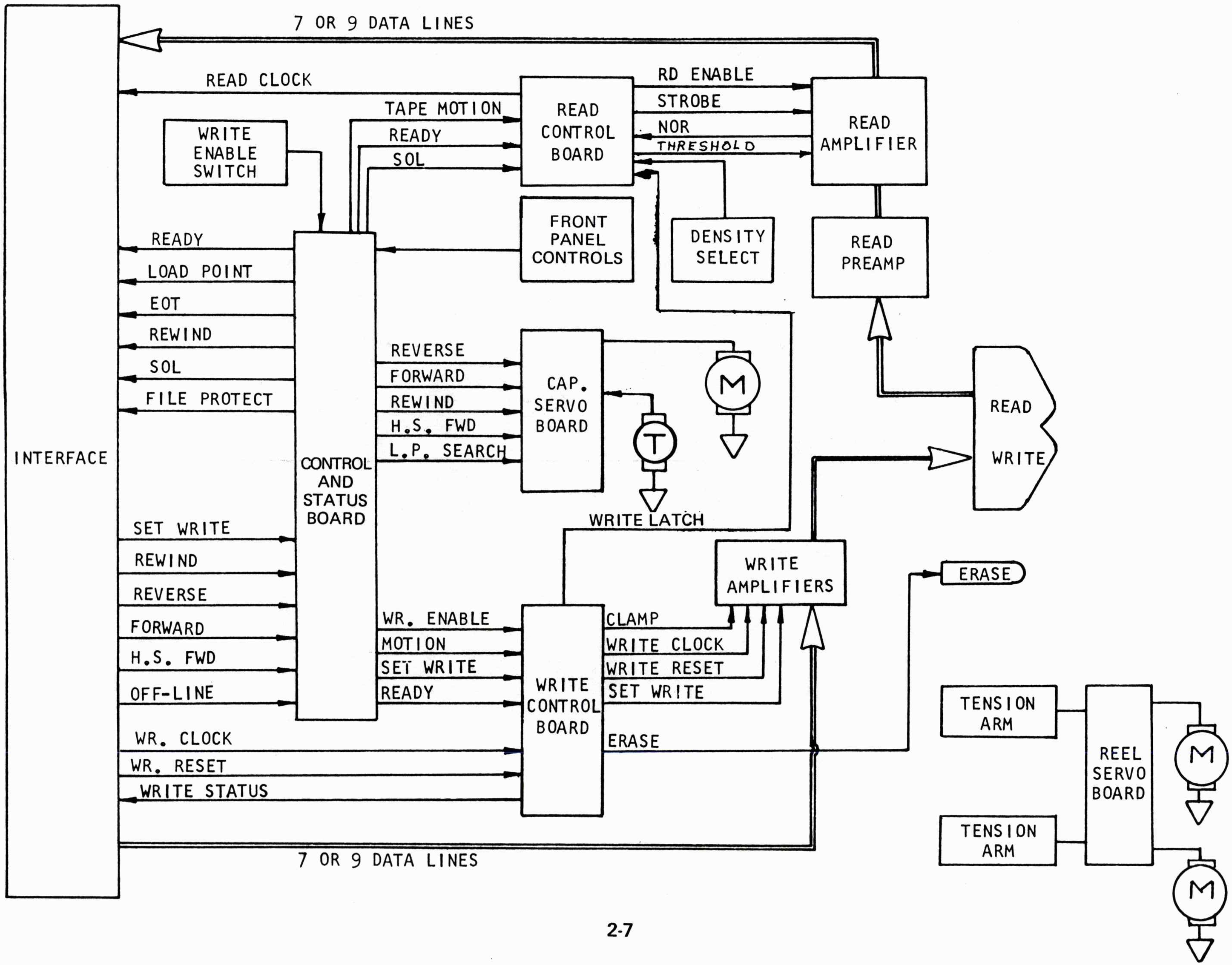

TENSION ARM ASSEMBLY (SUPPLY REEL MOTOR)
TENSION ARM LIMIT BUMPER STOP (4)
TENSION ARM (SUPPLY)
WRITE ENABLE ASSEMBLY
CONTROL SWITCH PCB
SUPPLY REEL MOTOR
PHOTOSENSE HEAD ASSEMBLY
REEL SERVO PCB
READ HEAD PREAMP PCB
DENSITY SELECT PCB
NOT ON 7970B HARPOON
TAPE DECK PAWL FASTENER
WRITE HEAD INTERCONNECT PCB
TENSION ARM ASSEMBLY (TAKEUP REEL MOTOR)
TAPE DECK MAINFRAME
UNIT SELECT CIRCUIT PCB
TAKEUP REEL MOTOR
CAPSTAN SERVO PCB
CAPSTAN SERVO ASSEMBLY
7970-A-5


control and status.
MULTIPLE-UNIT CONNECTOR
WRITE INTERCONNECT ASSEMBLY
MULTIPLE-UNIT WRITE-READ CONNECTORS
READ INTERCONNECT ASSEMBLY
WRITE DATA ASSEMBLY (MODULE)
READ DATA ASSEMBLY (MODULE)
UNREGULATED POWER SUPPLY CARD
REGULATED POWER SUPPLY CARD


+10V
3A
+20V
10A
+40V(SB)
2A
DJ1
+5V
DJ2
READ
DJ3
+12V
DJ4
DJ9
POWER
SUPPLY
PCB
-40V(SB)
2A
-20V
10A
DJ5
WRITE
DJ8
DJ6
-12V
DJ7
POWER
REGULATOR
PCB


Q2
R1
Q1
R2
Q3
C2
C5


HEAT
SINK
CR2
±20
CR1
±40V
CR3
+10V
T1
AC POWER
RECEPTACLE
115-230V AC
SLIDE SWITCH

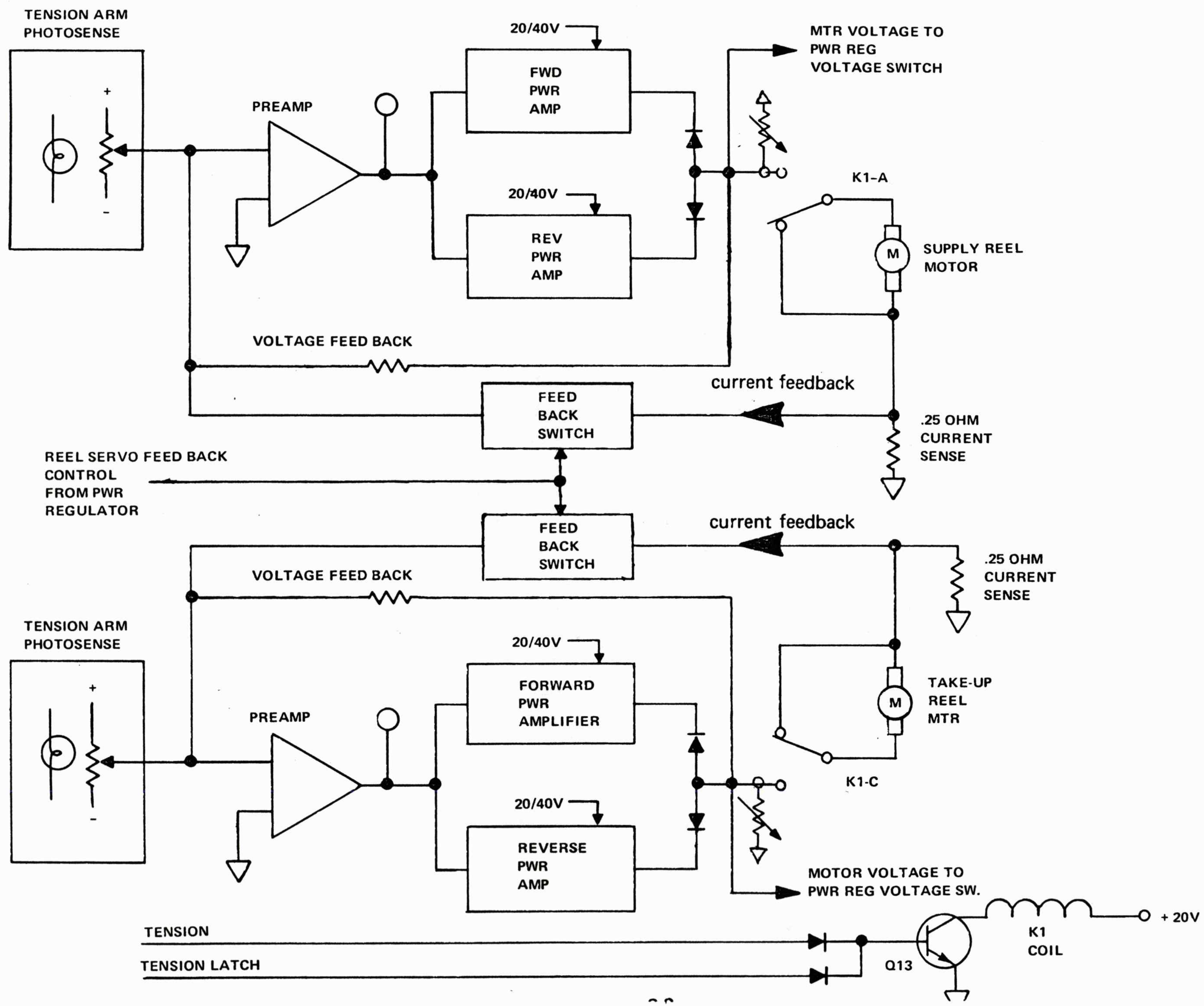

7 OR 9 DATA LINES
READ CLOCK
TAPE MOTION
READY
SOL
RD ENABLE
STROBE
NOR
THRESHOLD
READ CONTROL BOARD
READ AMPLIFIER
WRITE ENABLE SWITCH
FRONT PANEL CONTROLS
DENSITY SELECT
READ PREAMP
READY
LOAD POINT
EOT
REWIND
SOL
FILE PROTECT
INTERFACE
CONTROL AND STATUS BOARD
REVERSE
FORWARD
REWIND
H.S. FWD
L.P. SEARCH
CAP. SERVO BOARD
M
T
READ
WRITE
WRITE LATCH
SET WRITE
REWIND
REVERSE
FORWARD
H.S. FWD
OFF-LINE
WR. ENABLE
MOTION
SET WRITE
READY
WRITE AMPLIFIERS
ERASE
CLAMP
WRITE CLOCK
WRITE RESET
SET WRITE
ERASE
WRITE CONTROL BOARD
WR. CLOCK
WR. RESET
WRITE STATUS
TENSION ARM
REEL SERVO BOARD
TENSION ARM
M
M
7 OR 9 DATA LINES

SIMPLIFIED BLOCK DIAGRAM

The overall simplified block diagram of the 7970 Tape Unit functionally represents the transport, real electronics, write electronics, and interface or controller.

Note that all motion and status (except write status) lines enter or leave the control/status PC board. This is the heart of the 7970 transport which controls tape motion. All tape motion is provided by the capstan and its associated servo control. Tape storage is provided by the reel servo system. Mass tape storage is handled by the reels and low volume immediate access storage is provided by tension arm assemblies. Reel motion is controlled by photosense assemblies mounted on the tension arms which provide input to the reel servo relative to the position of the tension arms.

The write electronics circuits are controlled by the combined effort of the control/status board and the direct input from the interface. Data is received by the write amplifiers directly from the interface. The read electronics circuits are controlled by the control/status board. During a read operation, data is presented to the interface along with a read clock for interface timing.

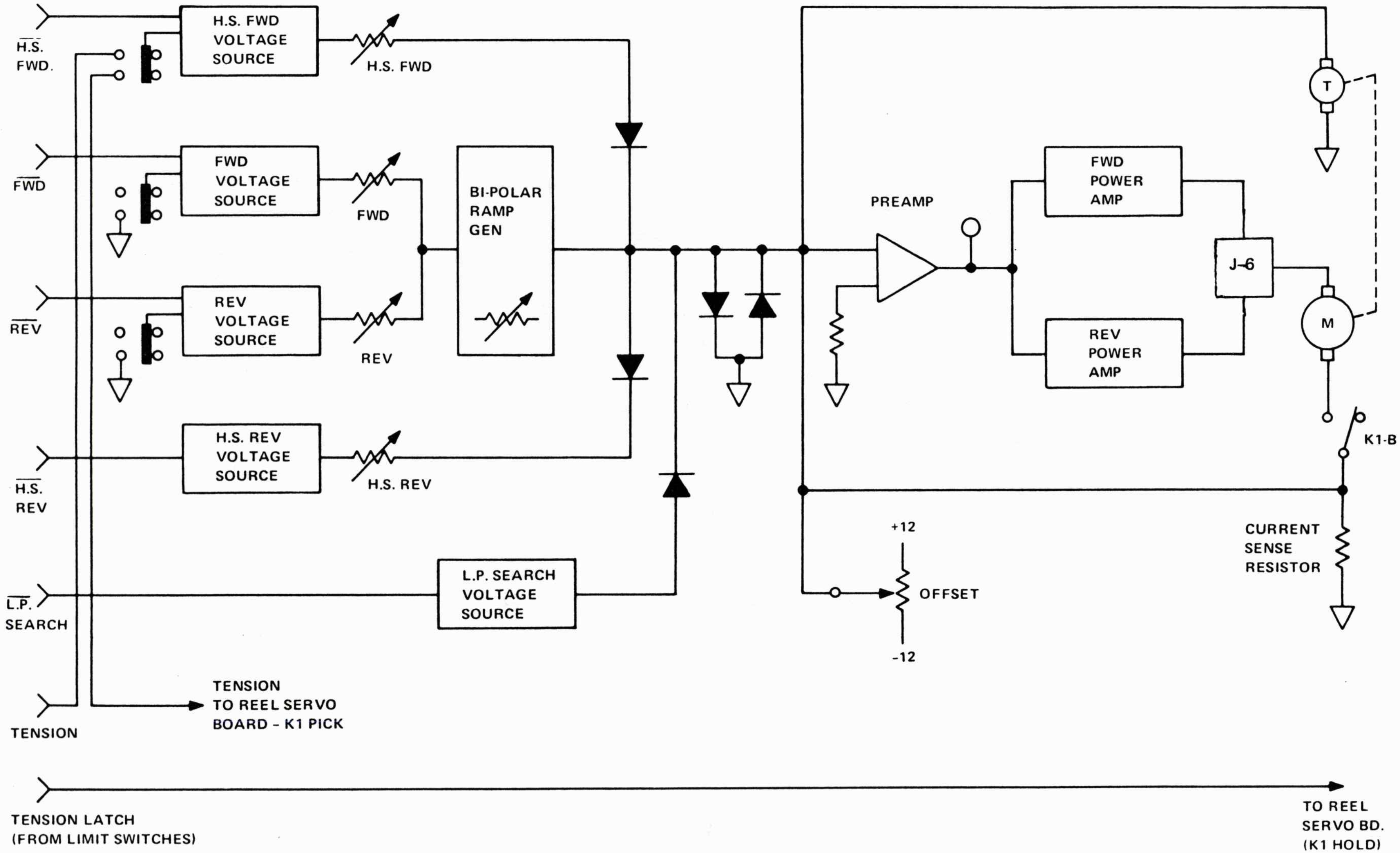

TENSION ARM
PHOTOSENSE
PREAMP
20/40V
FWD
PWR
AMP
20/40V
REV
PWR
AMP
MTR VOLTAGE TO
PWR REG
VOLTAGE SWITCH
K1-A
SUPPLY REEL
MOTOR
M
VOLTAGE FEED BACK
current feedback
FEED
BACK
SWITCH
.25 OHM
CURRENT
SENSE
REEL SERVO FEED BACK
CONTROL
FROM PWR
REGULATOR
current feedback
FEED
BACK
SWITCH
.25 OHM
CURRENT
SENSE
VOLTAGE FEED BACK
TENSION ARM
PHOTOSENSE
20/40V
FORWARD
PWR
AMPLIFIER
PREAMP
TAKE-UP
REEL
MTR
M
K1-C
20/40V
REVERSE
PWR
AMP
MOTOR VOLTAGE TO
PWR REG VOLTAGE SW.
+ 20V
K1
COIL
TENSION
TENSION LATCH
Q13

REEL SERVO BOARD

The reel servo board provides drive current for the reel motors relative to the tension arm position. Photosense assemblies on the tension arms provide input to the preamplifier proportional to the amount and direction of tension arm movement. The preamp simultaneously feeds two complimentary power amplifiers. The appropriate power amplifier drives the reel motor causing the tension arm to return to its center position.

Synchronous tape speeds utilize voltage feedback which allows the tension arms more travel and decreases the motor duty cycle. However, when a high speed operation takes place in a tape unit, the reel servo feedback control line goes negative and current feedback is gated into use. This provides more restrictive feedback and causes the motors to react more per change in tension arm position, thus keeping the tension arm more nearly centered. Supply voltage to the power amplifier is controlled by the voltage switch on the power regulator. The motor voltage is fed to the voltage switch which senses an excess of approximately 11 volts indicating the tension arm is approaching its limits. When this voltage is reached and the unit is in a high speed operation, the appropriate polarity 40 volt supply is gated to the servo amplifier. This allows the reel motors sufficient voltage to maintain the high speed operation. R104 and 106 are used at synchronous tape speeds to compensate for the non-linearity of the tension arm deflection.

CAPSTAN SERVO BOARD



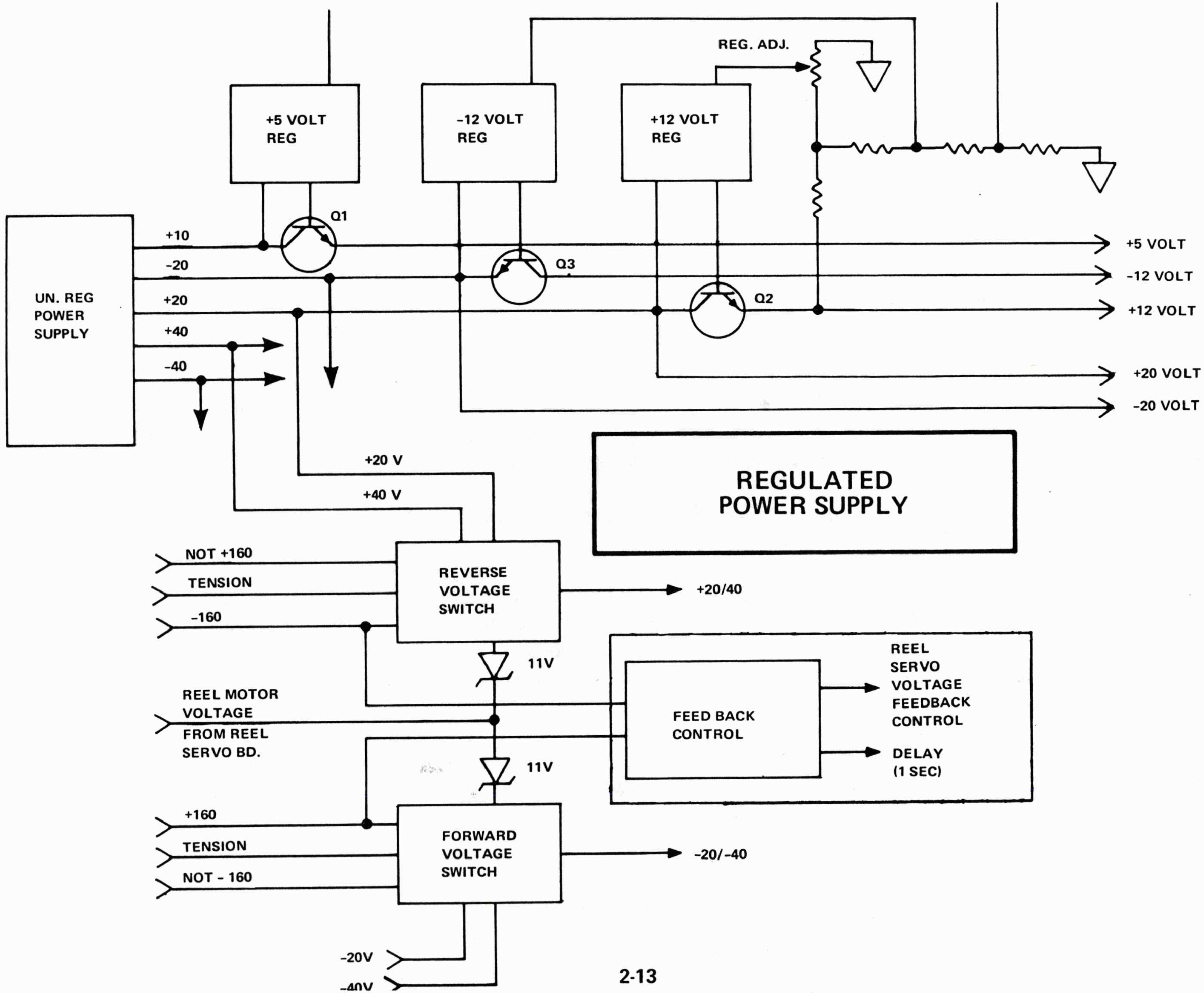
CAPSTAN SERVO

The capstan is the only device on the 7970 transport used for driving tape. Therefore, the capstan drive servo amplifier must be capable of moving tape at 5 different speeds; forward/reverse synchronous, high speed forward/reverse (160 IPS) and load point search speed (20 IPS). Capstan servo command lines enter the servo board from the motion control board and are applied to one of five reference voltage sources. Output from the high speed forward and high speed reverse voltage sources are adjustable and provide an input to a summing function. Output from the forward and reverse synchronous sources is adjustable and provide input to the bi-polar ramp generator. The slope of the ramp generator output is adjustable to permit changing the start-stop distance; and provides synchronous speed input to the summing junction. The load point search voltage source provides a non-adjustable 20 IPS drive source to the summing junction.

An offset potentiometer is used to compensate for any component leakage and to "zero" the summing junction.

The summing junction provides input to a preamp which simultaneously feeds two complimentary power amplifiers. The appropriate power amplifier drives the capstan motor causing tape motion. Velocity feedback voltage relative to capstan speed is developed by a tachometer and is presented to the summing junction along with motor current feedback which is developed across the current sense resistor. These two feedback voltages oppose the applied drive voltage to maintain a uniform tape speed.

A connector (J-6) is placed in one of 6 positions to allow correct operation of the capstan servo motor assembly. Damage to the P.C.A. or capstan motor may result if J-6 is missing or incorrectly installed. (See Page 4-4.)


+5 VOLT REG
-12 VOLT REG
+12 VOLT REG
REG. ADJ.
Q1
Q3
Q2
UN. REG POWER SUPPLY
+10
-20
+20
+40
-40
+5 VOLT
-12 VOLT
+12 VOLT
+20 VOLT
-20 VOLT
+20 V
+40 V
REGULATED POWER SUPPLY
NOT +160
TENSION
-160
REVERSE VOLTAGE SWITCH
+20/40
11V
REEL MOTOR VOLTAGE FROM REEL SERVO BD.
FEED BACK CONTROL
REEL SERVO VOLTAGE FEEDBACK CONTROL
DELAY (1 SEC)
11V
+160
TENSION
NOT - 160
FORWARD VOLTAGE SWITCH
-20/-40
-20V
-40V

POWER SUPPLY

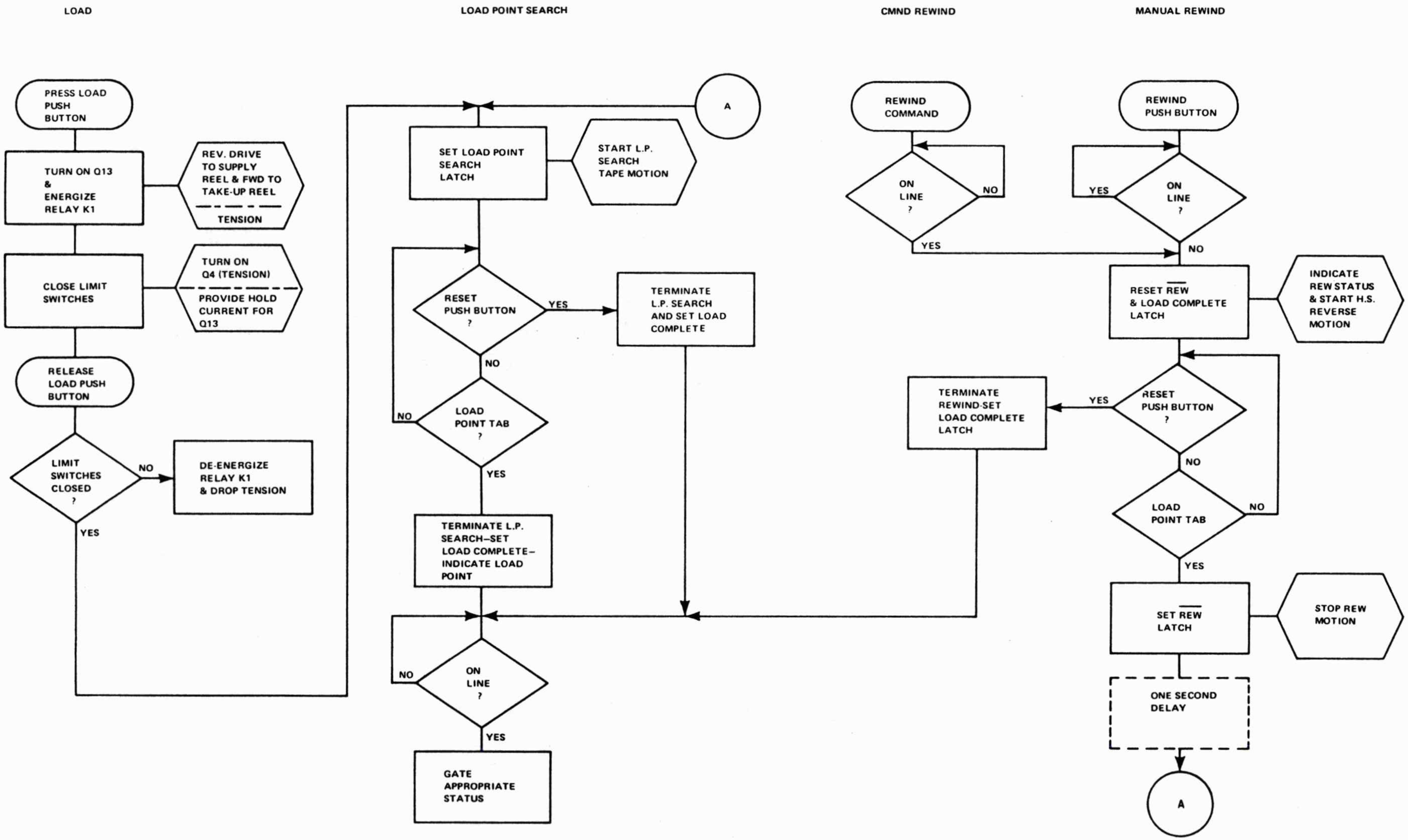
The power supply voltages can be divided into two major sections: the unregulated, and the regulated voltages. Primary input power must be 115 or 230 volts +10% at 48 to 66 Hz. Maximum power requirement is 400 VA at high line.

Output from 3 diode bridge networks in the unregulated power supply provide ±40 volts for the reel servo, ±20 volts, and +10 volts. The unregulated +20 volts supplies the +12 volts regulator which employs adjustable feedback for varying the output level. This output goes throughout the transport for utility use as well as to a voltage divider network on the regulator board. Taps from the voltage divider network are fed to the -12 and +5 volt regulator as a reference voltage. Consequently, as the +12 volt output is varied, the -12 and +5 volt outputs also vary.

During high speed operations the voltage switch on the regulator monitors the reel servo motor voltage. If the voltage from the servo amplifier exceeds 11 volts (indicating that the tension arm swing is approaching its limits) the voltage switch turns on, supplying 40 volts to the appropriate amplifier. Once the motor voltage returns to less than 11 volts, the voltage switch turns off and removes the 40 volt supply.

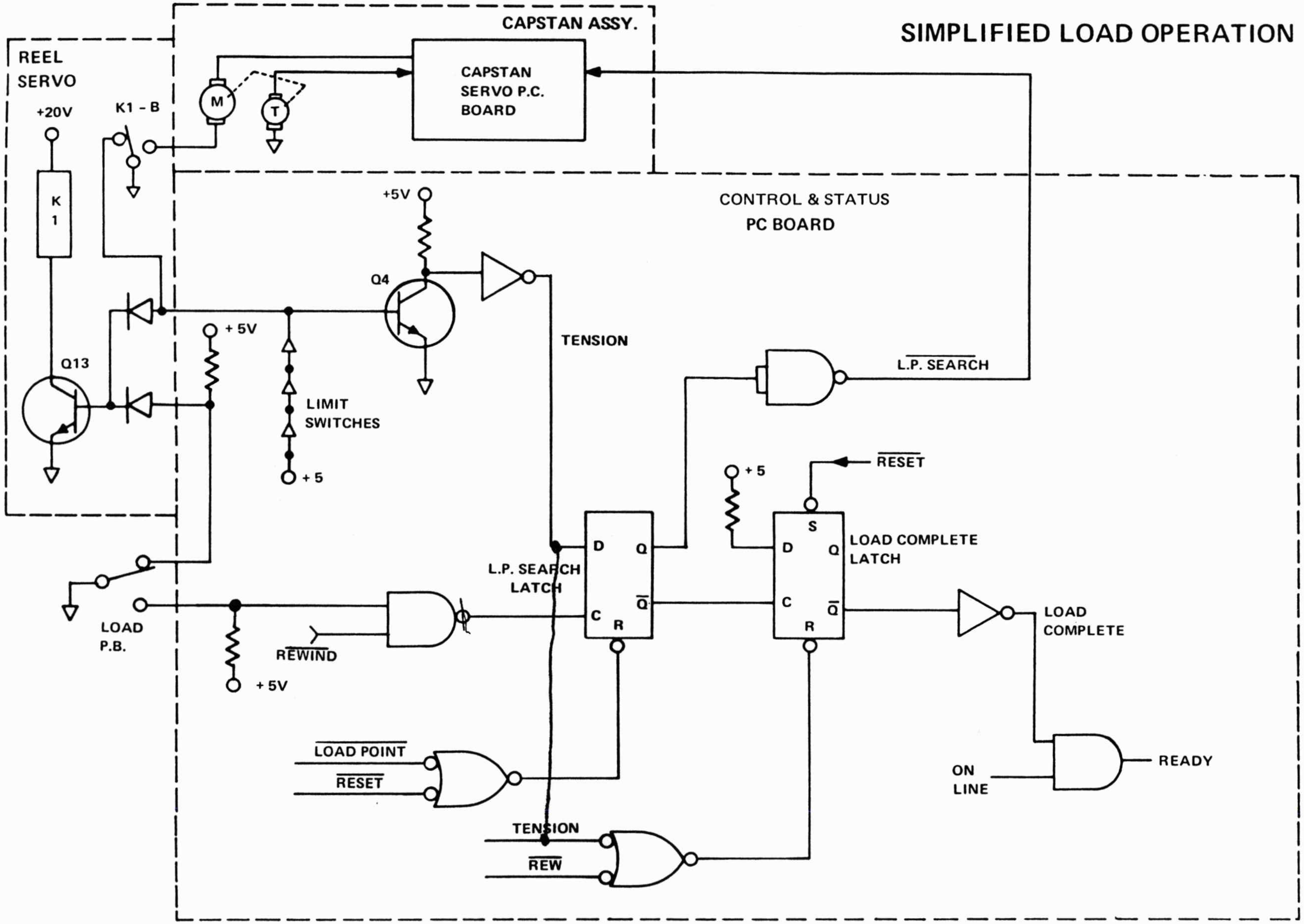
The feedback control circuit presents a signal to the reel servo board that causes the reel servos to operate on voltage feedback during normal operations and allows current feedback for high speed operations.

The 1 second delay is provided to prevent a false tape brake from being sensed when going from High Speed Forward or High Speed Reverse to another tape motion mode.


LOAD
LOAD POINT SEARCH
CMND REWIND
MANUAL REWIND
PRESS LOAD PUSH BUTTON
TURN ON Q13 & ENERGIZE RELAY K1
REV. DRIVE TO SUPPLY REEL & FWD TO TAKE-UP REEL
TENSION
CLOSE LIMIT SWITCHES
TURN ON Q4 (TENSION)
PROVIDE HOLD CURRENT FOR Q13
RELEASE LOAD PUSH BUTTON
LIMIT SWITCHES CLOSED ?
NO
YES
DE-ENERGIZE RELAY K1 & DROP TENSION
A
SET LOAD POINT SEARCH LATCH
START L.P. SEARCH TAPE MOTION
RESET PUSH BUTTON ?
TERMINATE L.P. SEARCH AND SET LOAD COMPLETE
LOAD POINT TAB ?
TERMINATE L.P. SEARCH–SET LOAD COMPLETE–INDICATE LOAD POINT
ON LINE ?
GATE APPROPRIATE STATUS
REWIND COMMAND
REWIND PUSH BUTTON
RESET REW & LOAD COMPLETE LATCH
INDICATE REW STATUS & START H.S. REVERSE MOTION
TERMINATE REWIND-SET LOAD COMPLETE LATCH
SET REW LATCH
STOP REW MOTION
ONE SECOND DELAY

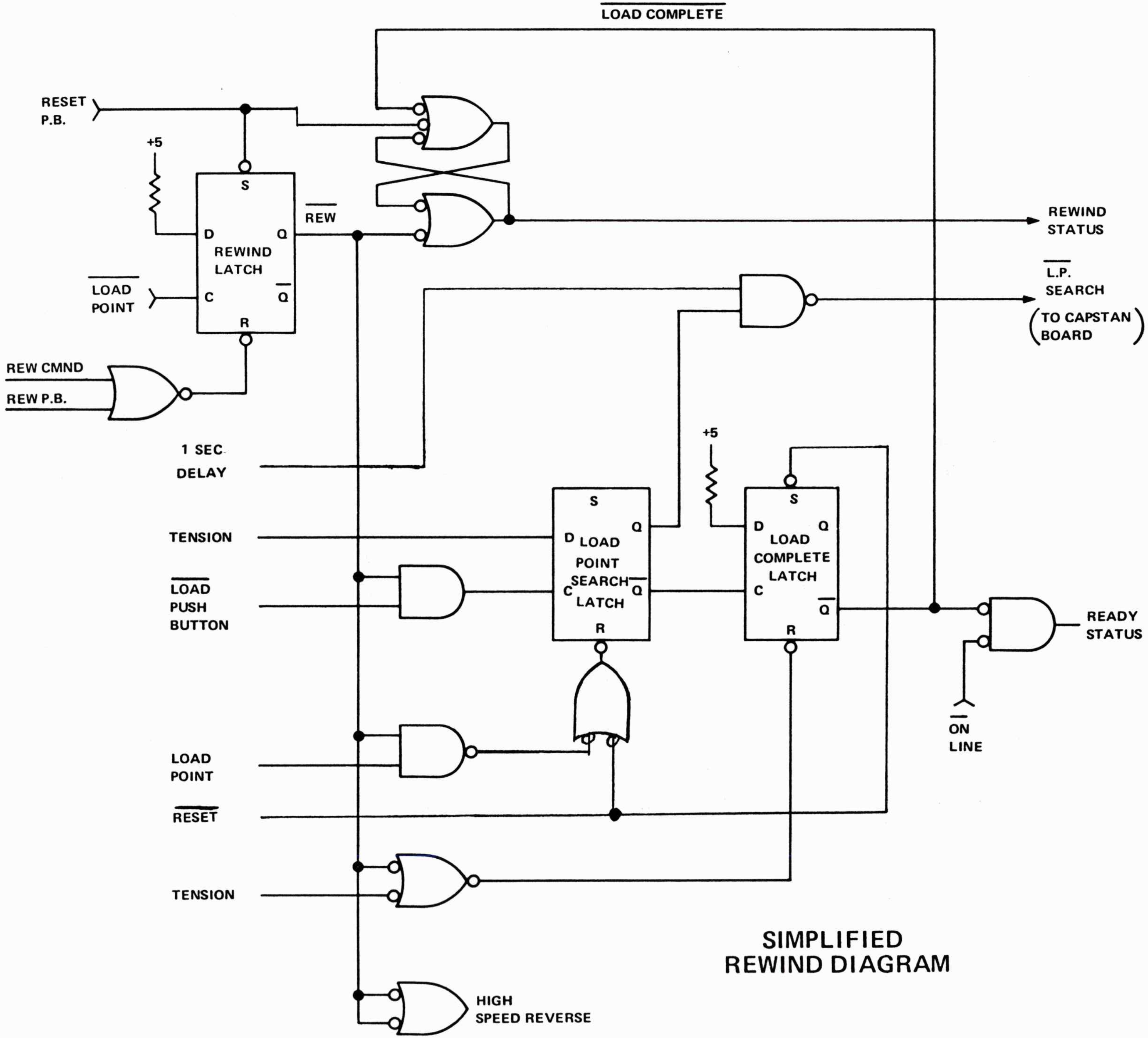
NOTES

SIMPLIFIED LOAD OPERATION



SIMPLIFIED LOAD OPERATION

The diagram representing a load operation includes portions of the reel servo, capstan servo, and the control and status PC assemblies. Pressing the load pushbutton initiates a load operation by turning on Q13 which in turn energizes relay K1 on the reel servo board. Energizing K1 transfers control of the capstan and reel motors to their respective servo amplifiers. Since, at this time the tension arms are at rest, the supply reel drives reverse and the take-up reel drives forward pulling the tension arms to their center position. This allows the tension arm limit switches to close and provide a holding path for relay drive transistor Q13. Transferring the limit switches also allows transistor Q4 to turn on which provides a "tension" indication to the L.P. search latch. Releasing the load pushbutton "clocks" the L.P. search latch to the set condition, initiating a L.P. search command for the capstan servo. Reaching the L.P. reflector tab or pressing the reset pushbutton generates a direct reset for the L.P. latch dropping the L.P. search command and clocking the load complete latch to the set state. This generates a load complete signal which is anded with ON LINE and sent to the interface as READY status. A second method of generating READY status is providing a rest signal to the direct set input of the load complete latch while tension is true. This directly sets the load complete latch. If the H/S FORWARD switch on the capstan servo PCA is placed in the true position K-1 will not energize. Hence the tape will not load. (See Figure 2-11.)

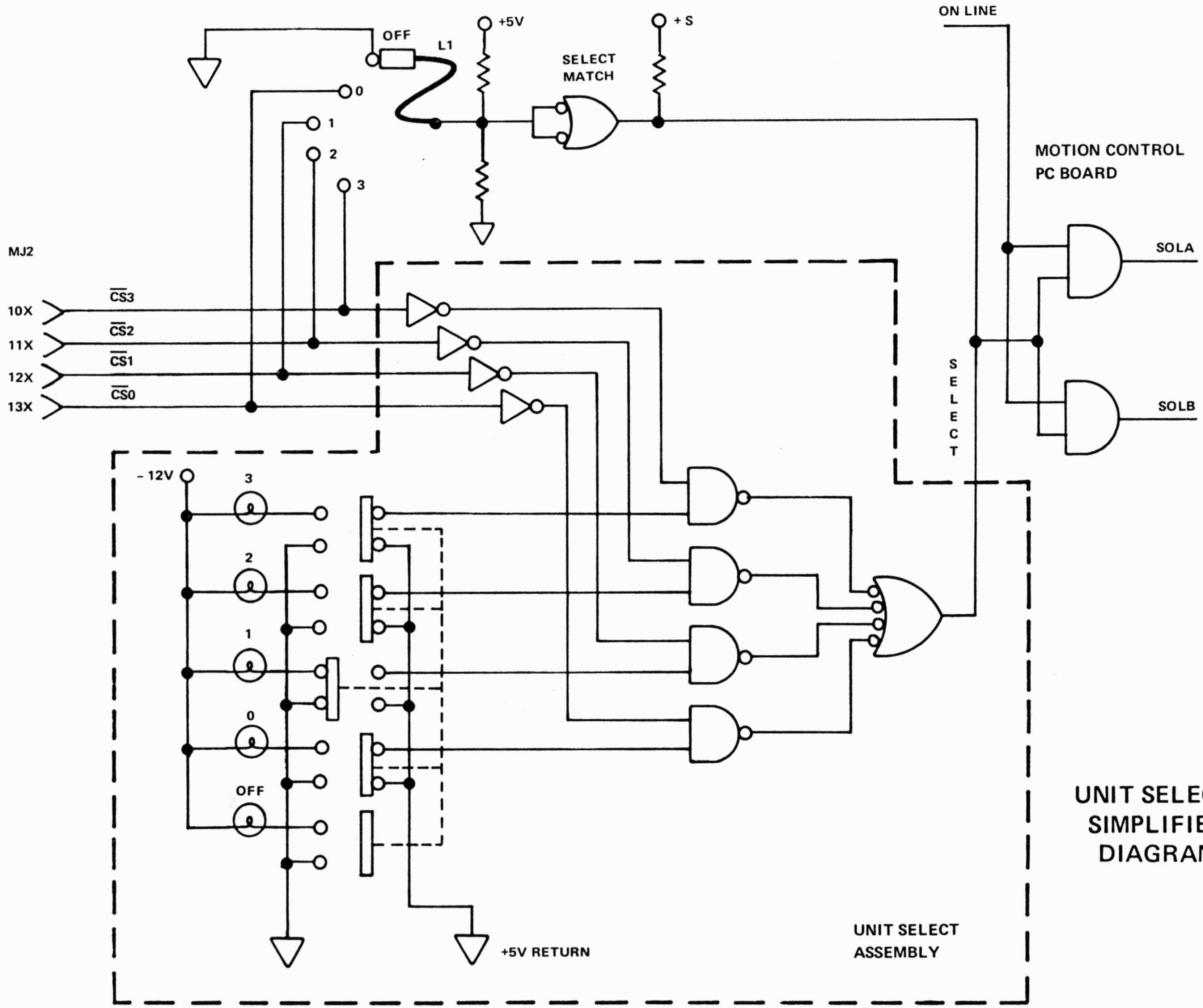


SIMPLIFIED
REWIND DIAGRAM

SIMPLIFIED REWIND OPERATION

A rewind operation is initiated by a REWIND command from the interface or by pressing the REWIND PUSHBUTTON. Both methods provide a direct reset to the rewind latch which generates a $\overline{\text{REW}}$ signal. The $\overline{\text{REW}}$ signal initiates a high speed reverse, sends rewind status to the interface, and resets the load complete latch which drops ready status.

With the tape unit rewinding (HS reverse), passing the load point clocks the rewind latch and negates $\overline{\text{REW}}$ command. Dropping the REW command, negates rewind status and clocks the L.P. search latch. Setting the L.P. search latch gates a load point search command to the capstan board if "delay" from the power regulator is positive. This delay is to insure that the rewind command is completely negated prior to starting the L.P. search. Completing the L.P. search (reaching the L.P. tab or pressing reset) sets the load complete latch which gates ready status to the interface.



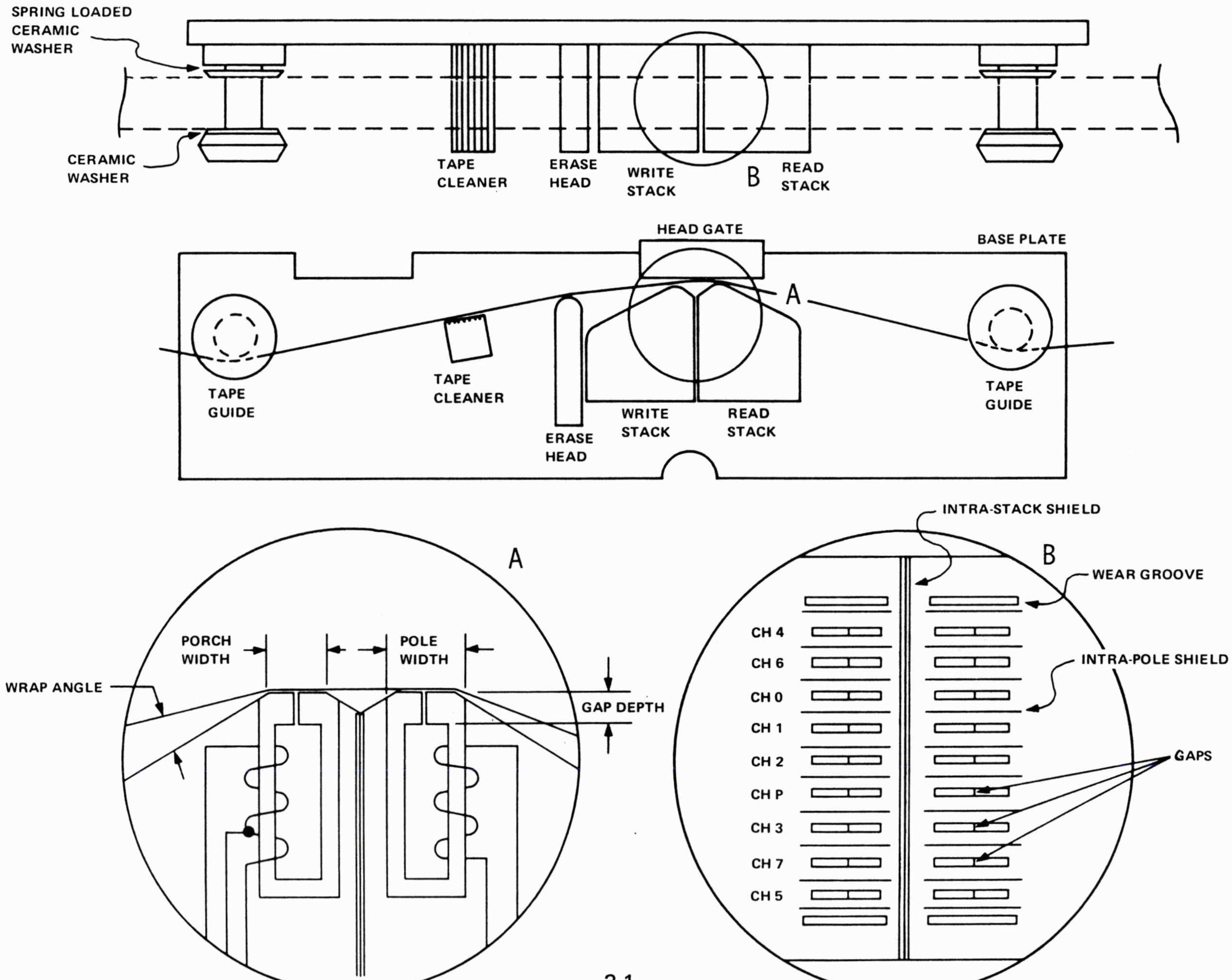
UNIT SELECT SIMPLIFIED DIAGRAM

UNIT SELECT OPTION

COMMAND SELECT ($\overline{CS}$) signals from the tape unit controller enter the motion control board through connector MJ2. If the unit does not have the Unit Select feature, jumper L1 on the motion control board is connected to the desired unit address pin. This allows unit selection when the C.S. code matches the position of jumper L1. If the tape unit has the Unit Select feature, jumper L1 is placed in the OFF position which disables the SELECT MATCH gate on the control board. When a C.S. signal enters the tape unit, it is anded with the outputs of the Unit Select switches. If the C.S. signal matches the selected switch, SELECT is anded with ON LINE to produce SOL A and SOL B.

HEAD AND DATA ELECTRONICS

HEAD ASSEMBLY (9 TRACK, ERASE, READ, WRITE)



HEAD ASSEMBLY

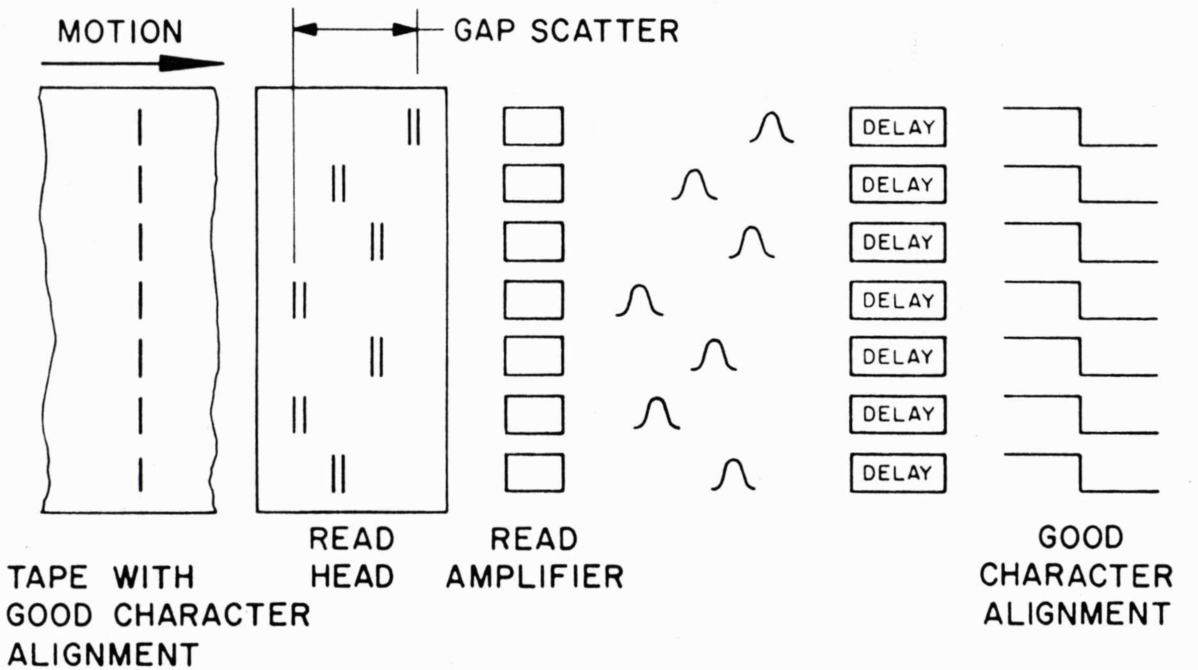
Since accurate tape guiding over the read/write head is imperative, all components in the head assembly tape path are mounted on a base plate. Tape guiding through the head area is accomplished by two tape guides. The edges of the tape are contacted by two ceramic washers, one fixed position (reference) and one spring loaded to allow for slight variations in tape width. In the forward direction, tape first contacts a slotted tape cleaner which scrapes any foreign particles from the tape prior to its reaching the head stacks. Tape then contacts a full width, high density erase head used to saturate tape in the reset flux state. After contacting the erase head it reaches first the write head stack then the read stack. A head gate near (but not contacting) the tape and over the read/write stack is used to reduce write to read stack crosstalk. A laminated intra-stack shield is placed between the stacks to further reduce the crosstalk. Each track in the head assembly has its own laminated read and write pole, including a coil winding and read/write gap. Separating the tracks are intra-pole shields to eliminate channel to channel crosstalk. As the tape passes over the write head it is magnetically saturated at the write gap. As it passes over the read head, a change in flux polarity induces a current in the read coil which is transmitted to the read electronics.

As a head wears, the smooth curve flattens on the top forming a "porch". If the porch reaches the edge of the pole, read or write errors may result. At this time the head may be refurbished or re-contoured. This may be accomplished only once since the re-contouring extracts approximately 0.005 inches from the total surface.

Wear grooves are cut into the read/write stacks at the point where the tape edges contact the stack. Their purpose is to decrease tape edge curl due to uneven wear across the head.

The wrap angle around the head stacks, erase head, and tape cleaner is extremely critical. Any alteration of the position of a component may cause characteristic changes in the entire head assembly.

STATIC SKEW
(GAP SCATTER)



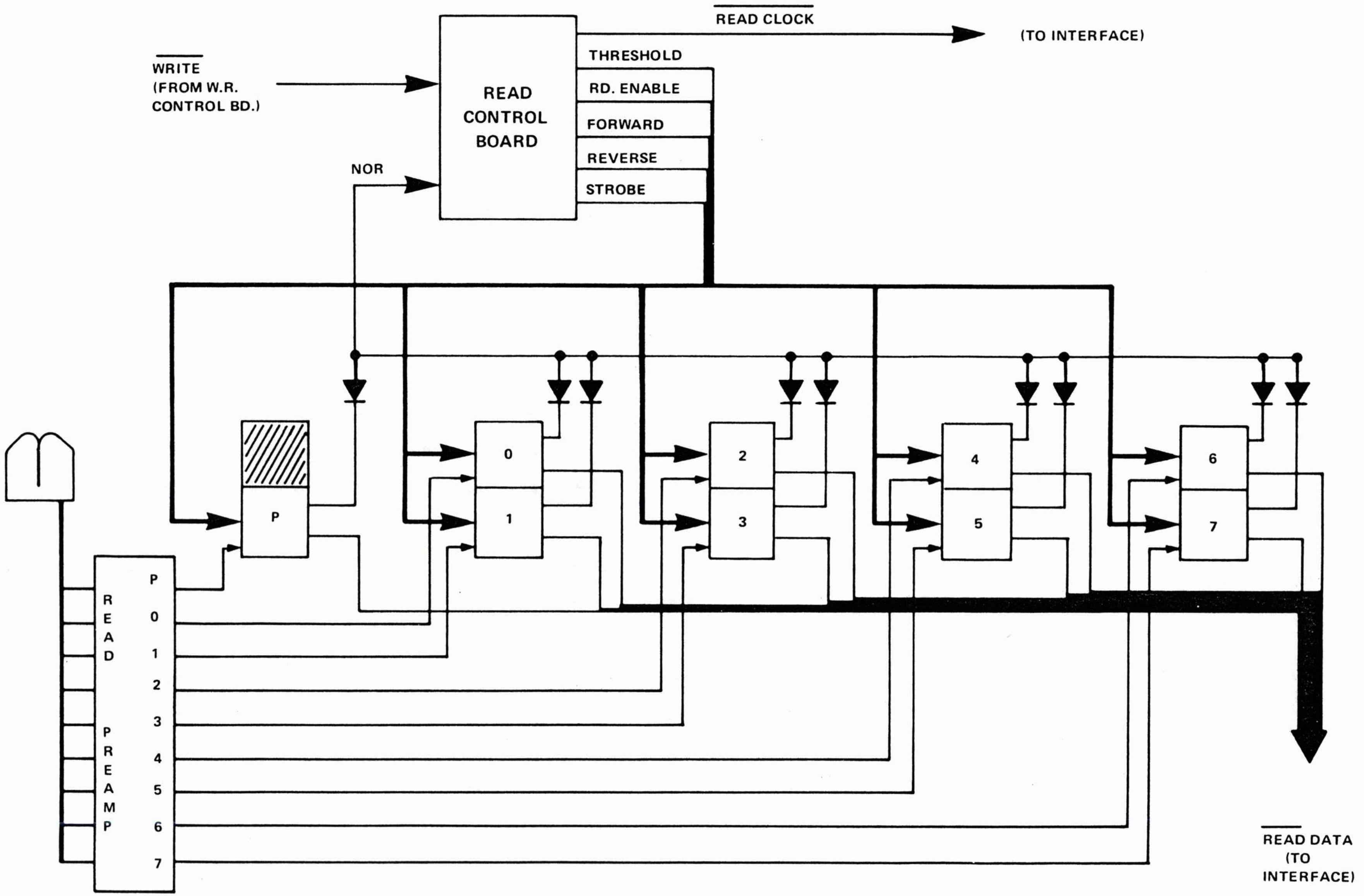
- TWO DELAY ADJUSTMENTS FOR EACH TRACK
- POTENTIAMETER ADJUSTMENT RATHER THAN DELAY TAPS

STATIC SKEW

When a digital magnetic tape head stack is constructed, slight variations may occur in gap alignment. Consider the misalignment (called gap scatter) of read gaps. As tape passes over the head the character (assuming good bit alignment) contacts the read gaps at different times depending on gap scatter. This time differential is called static skew.

To compensate for the effects of static skew, the outputs from the read head are presented to skew delay circuits. These delay circuits are adjustable and are used to electrically align all data bits of a character.

Write static skew effects character alignment when data is written on tape. Data is received from the interface in good electrical alignment. Each channel is then delayed and misaligned to compensate for write gap scatter. This ensures good character alignment on tape.

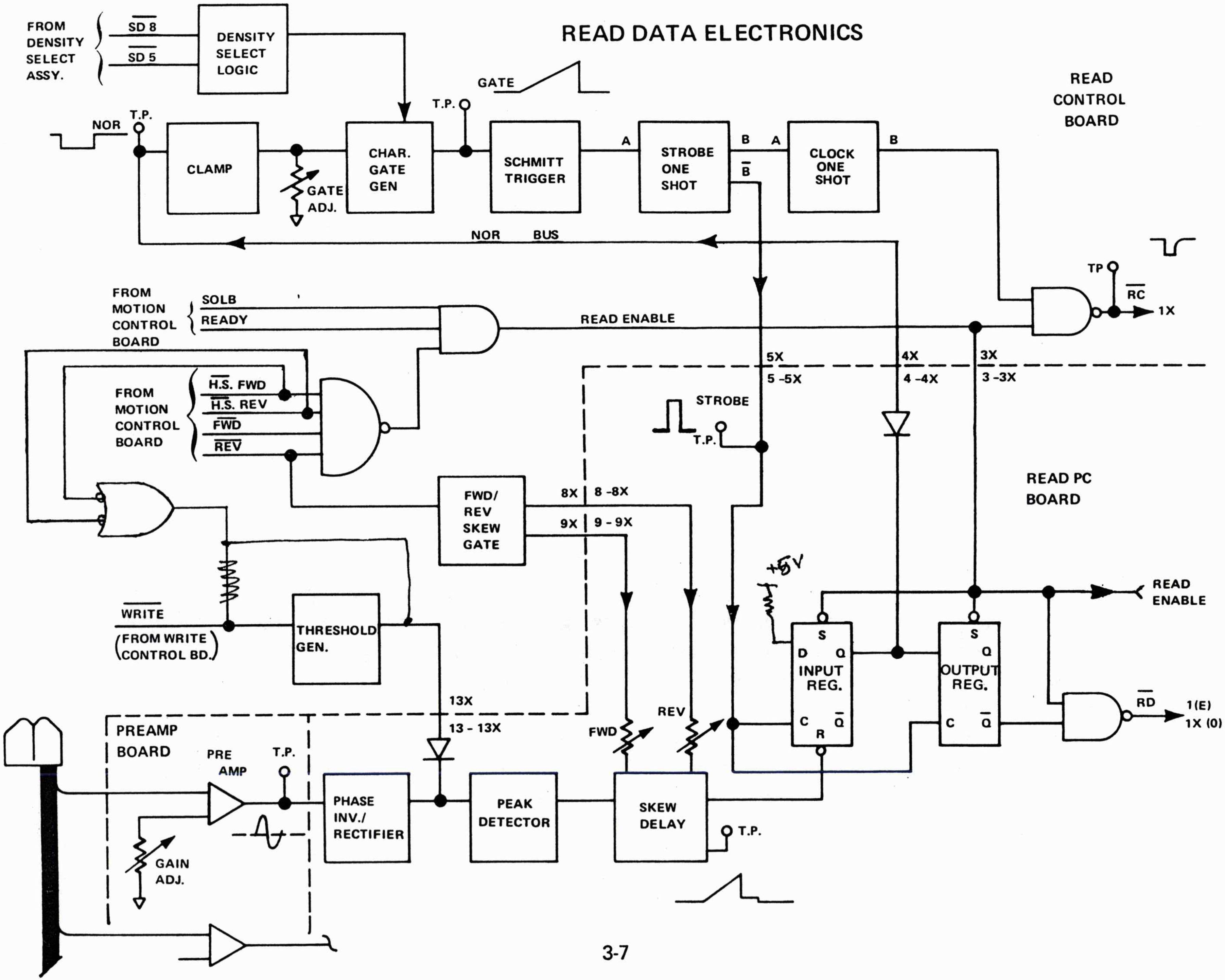


READ DATA ELECTRONICS

SIMPLIFIED READ DATA ELECTRONICS

When considering the overall operation of the read data electronics package, we see data is retrieved from tape by the read head and presented to the preamplifier. The read preamplifier amplifies the input from the head assembly and passes it on to the individual read channels. Also presented to the read channels are the bussed control lines from the read control board. STROBE is an internally used clock pulse. It is initiated by the NOR bus from the read channels and is used to clock data through the read channels. FORWARD and REVERSE are used to gate the proper skew delay circuits, and THRESHOLD signals the read channel when a write operation is in progress. READ ENABLE allows read data and read clock to be presented to the interface. READ CLOCK is sent to the interface to indicate data true.

READ DATA ELECTRONICS



READ ELECTRONICS

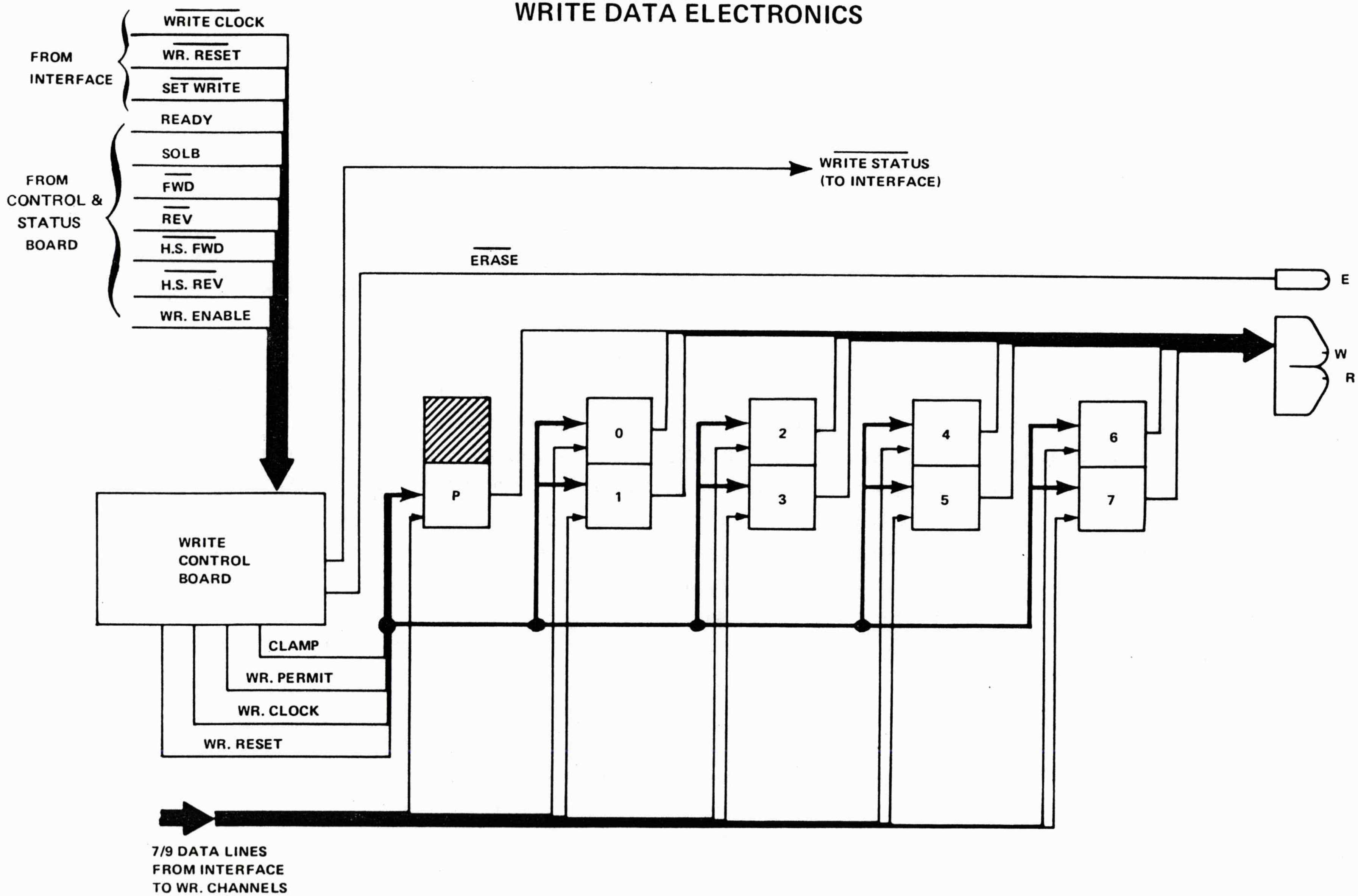
The function of the read electronics is to receive an analog signal from the head assembly and convert it to a digital output. The associated read electronics block diagram represents the read preamp, the read control, and one channel of a dual-channel read PC board.

Data from the read head is amplified by an adjustable single stage operational amplifier and sent to the read channel as an analog signal. This analog signal is received by a phase inverter/rectifier which converts it to a full wave rectified signal and feeds a peak detector. The threshold input establishes bias for the threshold detector diode causing approximately 40% base line clipping during write operations and 20% clipping during read operations. This clipping is accomplished to eliminate write to read crosstalk during write operations and provide noise immunity during read operations. The purpose of the peak detector is to represent the peak of the input signal with a sharp positive going edge of a square wave. This edge triggers the skew delay circuit which is used to compensate for static skew. Forward and reverse adjustments are provided for compensating for skew in both directions. When the skew delay ramp times out, a short duration negative going pulse directly resets the input register. Resetting the input register puts a "low" on the NOR bus. This "low" triggers the clamp circuit in the read control board, which in turn, starts the character gate time-out. The character gate ramp is coupled to the strobe one-shot through a Schmitt trigger. At the fall of the adjustable character gate ramp, the strobe one shot is fired, which sends a strobe pulse to the input and output registers as a clock. This strobe clocks the input register to its initial set condition and clocks the output register set for a logic zero and reset for a logic one. The trailing edge of the strobe triggers the clock one shot. This output is anded with READ ENABLE and presented to the interface as $\overline{\text{READ CLOCK}}$. The READ ENABLE signal is used to enable the read clock, input register, output register, and output gate.

The density select logic input to the character gate generator is used for 7 track tape units when reading tape written at densities other than 800 BPI. This makes it possible to lengthen the character gate for lower densities by selecting a different combination of density control lines.

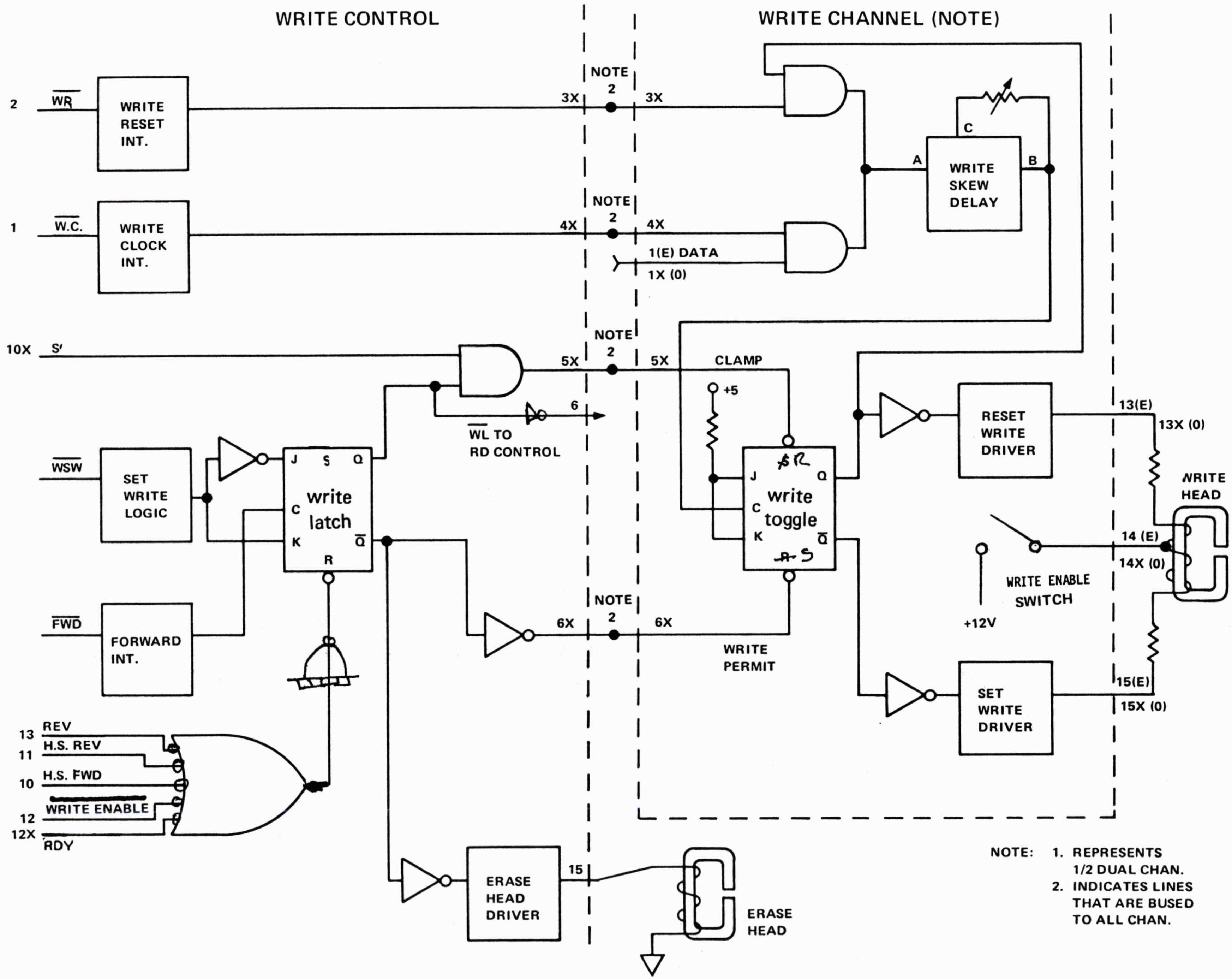
During high speed read operation the threshold bias level is changed to maintain approximately 40% baseline clipping for proper noise immunity.

WRITE DATA ELECTRONICS



SIMPLIFIED WRITE ELECTRONICS

In the simplified diagram of the write data electronics, the write control board and 9 data channels are functionally represented. WRITE CLOCK, WRITE RESET (WRS), SET WRITE (WSW) and DATA lines are received directly from the motion control board. The write control board provides CLAMP and WRITE PERMIT control lines, WRITE CLOCK and WRITE RESET to the write channels as well as gating erase current to the erase head and sending write status to the interface. Data lines are received directly from the interface and are controlled internally with WRITE CLOCK. Note that all control lines are bussed to all data channels simultaneously.



NOTE:
1. REPRESENTS 1/2 DUAL CHAN.
2. INDICATES LINES THAT ARE BUSED TO ALL CHAN.

WRITE ELECTRONICS

A forward command from the interface is applied to the FORWARD INTEGRATOR on the Write Control Card. The output of the integrator clocks the write latch. If SET WRITE is true and direct reset is false (high), the WRITE LATCH is set. This gates erase head current and sends WRITE PERMIT and CLAMP to all write channels. Write clocks ($\overline{\text{WC}}$) from the interface enter the write clock integrator. The integrator output is "anded" in each channel with data and sent to the write skew delay one shot. A logic one causes the write skew delay to trigger and provides a clock for the write toggle. When both CLAMP and WRITE PERMIT are false, (low) and Q and $\overline{\text{Q}}$ outputs of the write toggle are held high which degates both write drivers. With CLAMP and WRITE PERMIT true (high), the write toggle "flips" with each clock from the write skew delay which alternately causes the reset and set write drivers to conduct.

+12 VDC is applied to the center tape of the write head through the WE switch.

The quiescent state of the WRITE TOGGLE is reset, causing the reset write driver to drive current thru one half of the center tapped write head. This saturates tape to the same polarity as the erase head. Each data "one" bit from the interface "flips" the toggle, which reverses the direction of saturation. After all data characters have been written, WRS (write reset) is sent from the interface to the transport write control board. WRS is "anded" with the Q output of the WRITE TOGGLE and generates one more flux reversal if an odd number of bits was written in the channel. All write toggles are therefore left in the reset state. The LRC character is written on the tape as a result of returning all the 7 or 9 write toggles to the reset state.

MAINTENANCE PROCEDURES

NON-SEQUENTIAL ADJUSTMENT PROCEDURES

TENSION ARM

1. Ensure that a minimum clearance of 0.010 inch exists between the cell and the outer side of the photosense mask.
2. Remove the supply and take-up reels from the machine and slightly loosen the socket screw holding the mask.
3. Hold the upper tension arm in the center and press the load pushbutton.
4. Adjust the mask to eliminate reel motor motion and tighten the socket screw.
5. Place a pencil or similar device through the casting slot for the upper tension arm. (This prevents the tension arm from tripping the upper limit switch.)
6. Loosen the socket screw holding the lower tension arm mask and hold the tension arm in the center position.
7. Press the load pushbutton and adjust the photosense mask to eliminate lower reel motor motion.
8. Tighten the photosense mask socket screw.
9. Mount a scratch tape and press "LOAD".
10. Perform a "fine adjustment" to the photosense masks with tension applied.

TENSION ARM LIMIT SWITCHES

1. The tension arm limit switches should be positioned such that when the tension arm is fully against the rubber bumper:
   a. The roller on the microswitch should be approximately at the high point of arm diameter without being past the center.

b. When the arm is within 1/8 inch of the bumper stop, the microswitch roller must contact the tension arm. Also, there must be further positive movement of the switch between the point at which the switch closes and the tension arm is fully against the rubber bumper.

NOTE

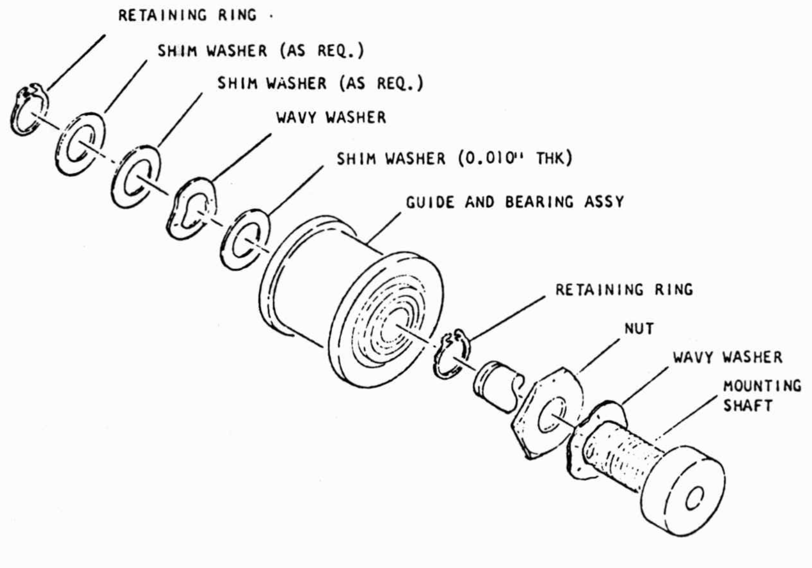
These parameters may be met by rotating the limit switch mounting bracket and by adjusting the position of the switch on the mounting bracket.

TAPE GUIDE PRE-LOAD PROCEDURE (Refer to Figure)

NOTE

This procedure is critical and must be accomplished if the guide is replaced or removed.

1. Install components as shown. Use retaining ring pliers to avoid distorting the retaining ring.
2. Check tape guide end play and add or remove shim washers as necessary to just remove all end play.
3. Spin bearing assembly to check for drag. If the guide does not spin freely, loading may be excessive; recheck end play.



GUIDE AND BEARING ASSEMBLY

REEL HOLD-DOWN KNOB TENSION

NOTE

With the reel hub locking lever out it should be possible to place a reel over the hold-down knob with a minimum of interference. With the hub locking lever closed, it should not be possible to move the reel by hand. If reel tension is insufficient, proceed as follows:

1. Remove the reel and loosen the hub posidriv screw.
2. Hold the rubber expansion ring firmly and rotate the hold-down knob housing approximately 1/8 turn clockwise. (Tighten)
3. Tighten pozidriv screw and check performance. Repeat procedure if necessary.

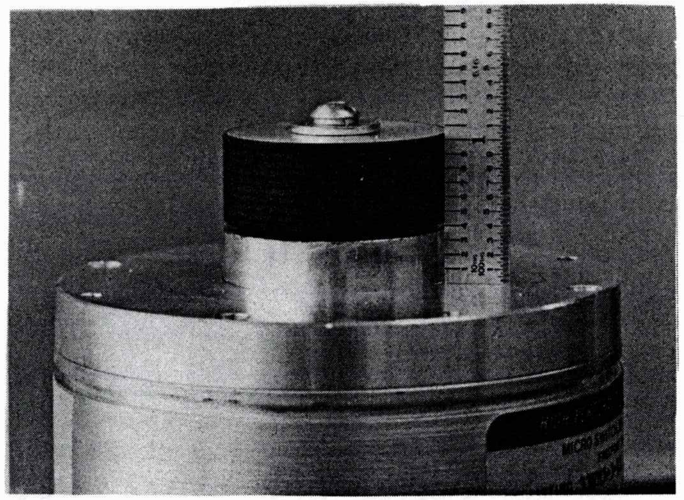
PHOTOSENSE HEAD POSITION

1. Mount a scratch tape and provide tension.
2. Loosen the mounting screws on the photosense assembly and position the head approximately 1/8 inch from and parallel to the tape.
3. Tighten the mounting screws and check for proper EOT/BOT detection.

HIGH SPEED CAPSTAN INSTALLATION PROCEDURE
HP 07970-60141

Tools Required:

1. Six inch steel scale with 1/64" graduations.
2. Allen wrenches SET.



Procedure:

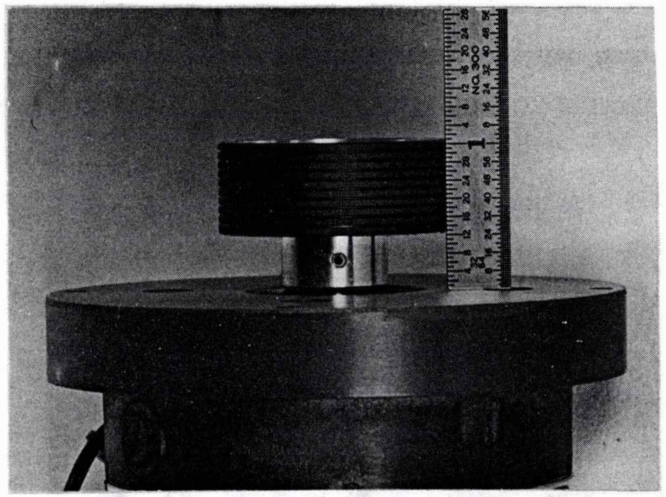
1. Disconnect capstan and tachometer plugs from the capstan servo board.
2. Remove 4 cap screws holding the capstan assembly to the casting.
3. Remove the cap screw holding the capstan to the motor shaft and remove the capstan.
4. Position the new capstan on the motor shaft.
5. Tighten the cap screw. The front edge of the capstan should be 1-1/32" ±1/64" from motor mounting surface.
6. Re-install the motor and connect the associated plugs.

LOW SPEED CAPSTAN INSTALLATION PROCEDURE

HP 07970-60140

Tools Required:

1. Six inch steel scale with 1/64" graduations.
2. Allen wrenches (size 9/64" and 0.050").



Procedure:

1. Disconnect capstan and tachometer plugs from the capstan servo board.
2. Remove 4 socket screws holding the capstan assembly to the casting.
3. Loosen the 2 set screws holding the capstan to the motor shaft and remove the capstan.
4. Position the new capstan on the motor shaft such that the front edge of the capstan is 1-1/32" ±1/64" from motor mounting surface.
5. Tighten the set screws.
6. Re-install the motor and connect the associated plugs.

7970 SEQUENTIAL ADJUSTMENT PROCEDURES

EQUIPMENT REQUIRED:

1. Oscilloscope — HP 180 or equivalent with times 10 probes
2. Frequency Meter (sample rate at least 1 sec)
3. Skew Alignment Tape (HP 9162-0027)
4. Standard Speed Tape (HP 5080-4525)
5. Computer grade Scratch Tape

PROCEDURE:

CAUTION

Be sure capstan servo PCA (connector J-6) is placed in the correct position. Damage to PCA or motor may result.

NOTE

The following adjustments are sequence sensitive and must be done in succession.

Power Regulator:

1. Calibrate the oscilloscope and connect the probe to the +5 volt pin on the power regulator printed circuit board.
2. Adjust potentiometer R4 for +5 volts ±0.010 volts.
3. Ensure that the +12 and −12 volt supplies are within ±0.300 volts of nominal.

REEL SERVO ADJUSTMENTS

1. Load a short length of tape onto the transport and bring to load point.

NOTE

The following adjustments determine the peak deflections of the tension arms. The amount of deflection desired is a function of the synchronous speed. At the highest speed (45 ips) the deflection is set so the tension arms deflect to the outer marks located on the back side of the casting, both in forward and reverse drive modes. At lower speeds the amount of deflection is smaller (i.e: at 25 IPS the deflection is about half (25/45) the amount at 45 IPS). Due to non-linearity of the tension arm transducer the swing of the tension arm may be unsymmetrical in forward and reverse drive. In this event, the tension arm mask should be turned so that the swing is symmetrical in the forward and reverse drive modes. (This will mean the tension arm will not be centered when there is no tape motion and is normal.)

2. With the supply reel loaded with approximately 200 feet of tape, rotate the supply (Lower) potentiometer fully clockwise and run the tape unit in the forward mode. Rotate the SUPPLY (lower) potentiometer counter clockwise for the proper deflection.

3. Stop tape motion and put in reverse drive and make sure the amount of deflection is the same as in forward drive. If not, readjust the mask position until symmetrical swings of the proper amount are achieved.

4. Repeat procedure for the take-up reel with approximately 200 feet of tape on the take-up reel.

5. Tape units with synchronous speed less than 45 ips only require that the supply potentiometer and take-up potentiometer be adjusted for maximum gain. The symmetrical swing is adjusted by moving the tension arm mask.

NOTE

Final reel servo adjustments must be made after the capstan servo adjustments. The capstan speed must be within tolerance in order to properly adjust the reel servo. However, tension must be maintained in order to make the capstan servo adjustments. If the tape unit does not maintain tension, perform the reel servo adjustments initially, complete the capstan servo adjustments, and repeat the reel servo adjustments.

CAPSTAN SERVO ADJUSTMENTS

Offset:

1. Connect the oscilloscope to the preamp test point on the capstan servo board.
2. Adjust the offset potentiometer until a slight movement (1/10 turn) causes the preamp output to cross-over (jump from negative to positive or positive to negative). The crossover point should be between 0.5 and 0.7 volts.

Tape Speed Adjustments:

NOTE

For accurate speed adjustment, the HP speed test tape (HP 5080-4525) should be used when performing the following adjustments. If a speed tape is not available, the standard skew alignment tape may be used if speed accuracy no more accurate than 5% is sufficient.

1. Mount the standard tape and calculate the data transfer rates for both high speed (160 IPS) and synchronous (nominal) speed.

NOTE

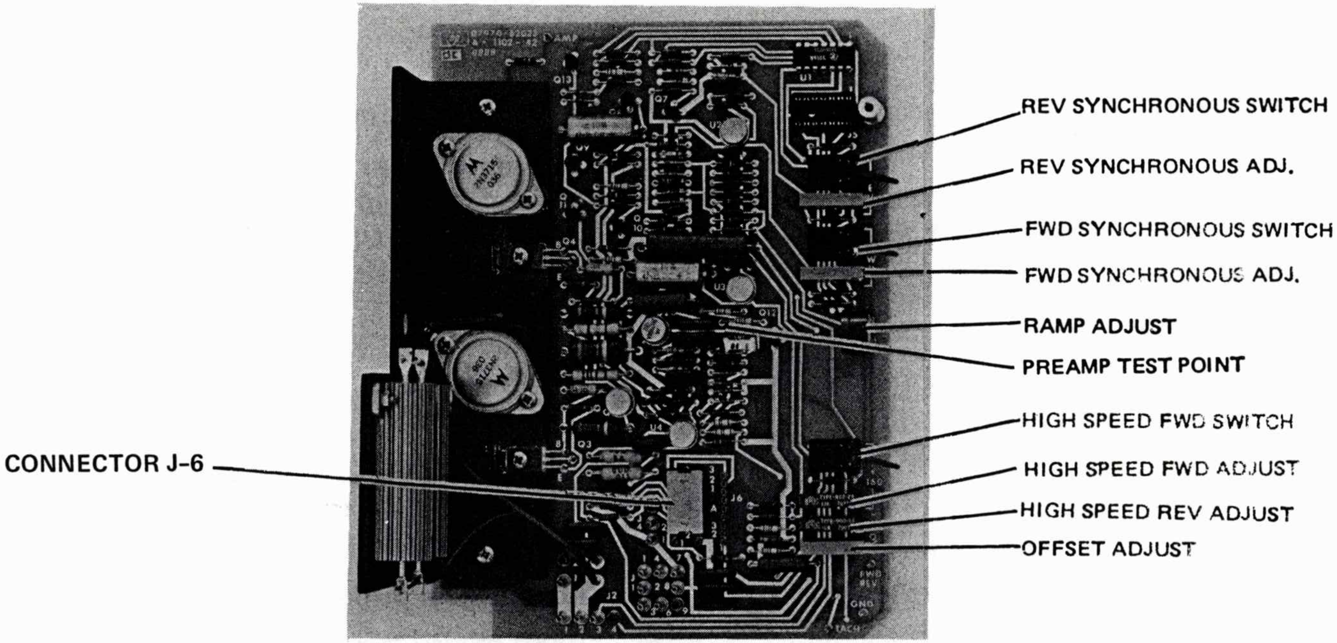
For this example we will assume that synchronous speed is 25 IPS and that track 3 of the HP speed tape is being used. Track 3 of the speed tape is recorded at 10 kHz at 30 IPS. Therefore, playback frequency at 25 IPS is 8.33 kHz. (direct ratio)

If a standard skew tape is being used, data transfer rate is calculated using the formula:

data rate = density x speed

However, calculated rate into a sinewave frequency meter must be divided by two compensate for each peak representing a logic one.

2. Connect the frequency counter to track 3 preamp test point (9 track, channel 3; 7 track, channel 5).



CAPSTAN BOARD

3. Provide synchronous forward motion and adjust the "FWD" potentiometer on the capstan servo for calculated data rate frequency meter reading (variable depending on tape unit speed). Stop the transport.

NOTE

When using the skew alignment tape, calculated transfer rate frequency must be divided by two to compensate for each peak representing a logic one.

4. Provide synchronous reverse motion and adjust the "REV" potentiometer on the capstan servo for calculated data rate frequency meter reading (variable depending on tape unit speed). Stop the transport.

5. Provide high speed forward motion and adjust the "+160" potentiometer on the capstan servo for calculated high speed data rate frequency meter reading.

6. Provide high speed reverse (rewind) motion and adjust the "–160" potentiometer on the capstan servo for calculated high speed data rate frequency meter reading. Stop the transport.

Ramp Adjustment

1. Mount the standard skew alignment tape.
2. Calculate start time using the formula:

   START TIME (msec) = 375/SPEED (IPS) -0.5 msec

   (25 IPS TRANSPORT START TIME = 14.5 msec)

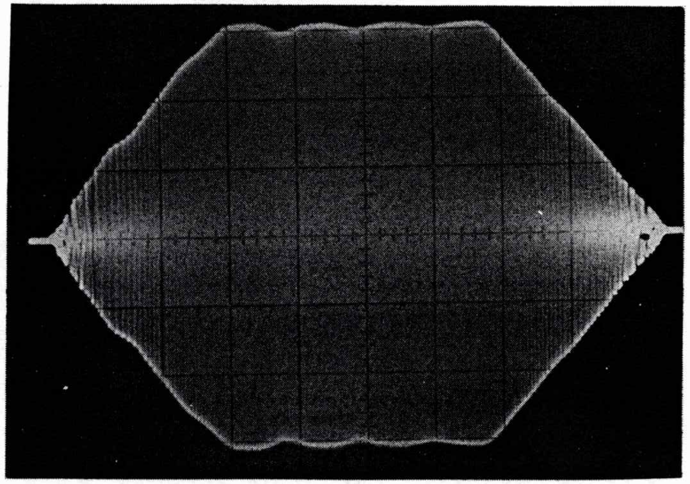
3. Provide alternate forward/stop commands to the tape unit.

   NOTE

   This may be done under computer control, or with an off-line test device such as the HP 13191A Test Card.

4. Sync the oscilloscope externally on the forward drive command (TP9 on the motion control board) and scope preamp channel 3 output. Observe wave shape.

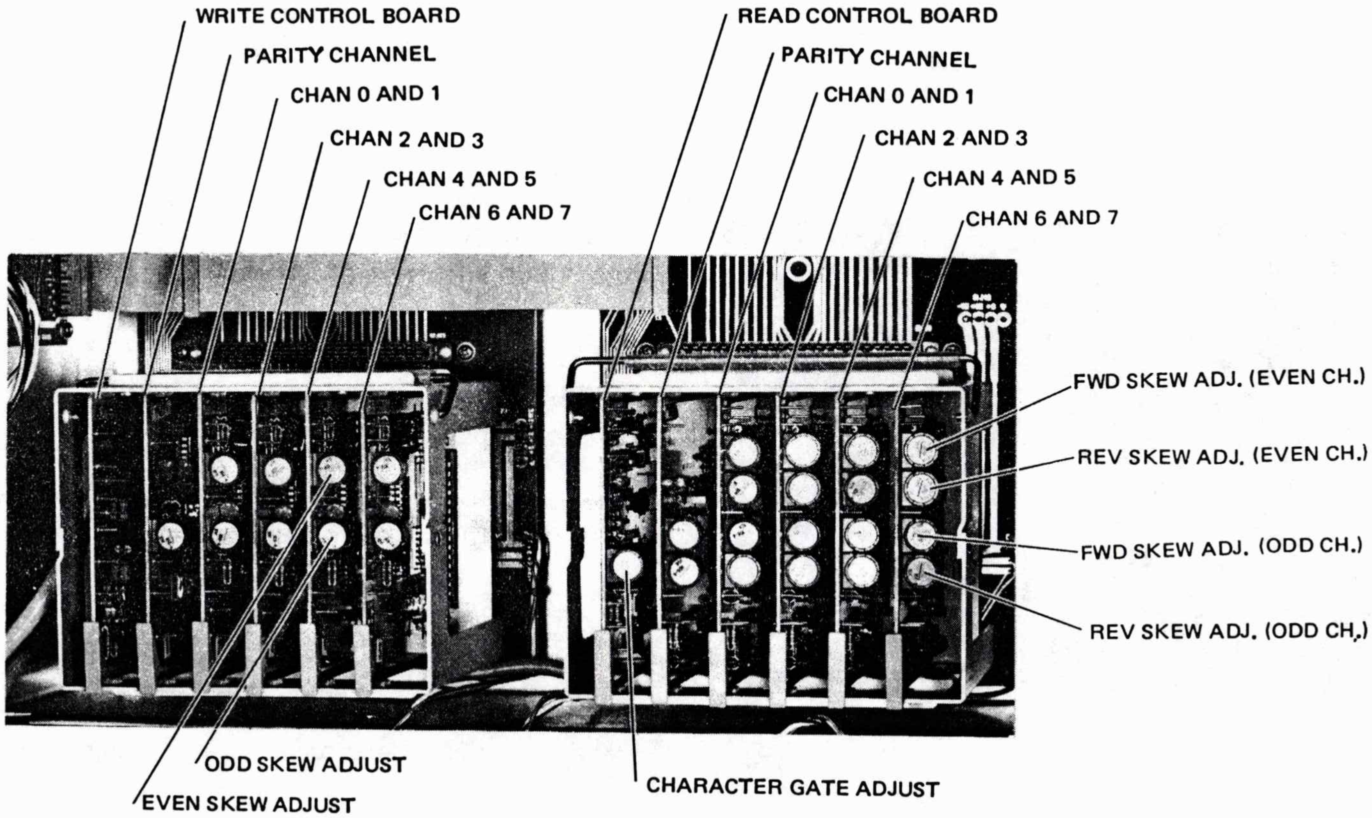
5. Adjust the ramp potentiometer for calculated start time from forward to steady data.



RAMP ADJUSTMENT
START/STOP ENVELOPE
VERT = 1 v/cm
HORIZ = 5 ms/cm

Reel Servo Final Adjustment

1. See Reel Servo Adjustment.


WRITE CONTROL BOARD
PARITY CHANNEL
CHAN 0 AND 1
CHAN 2 AND 3
CHAN 4 AND 5
CHAN 6 AND 7
READ CONTROL BOARD
PARITY CHANNEL
CHAN 0 AND 1
CHAN 2 AND 3
CHAN 4 AND 5
CHAN 6 AND 7
FWD SKEW ADJ. (EVEN CH.)
REV SKEW ADJ. (EVEN CH.)
FWD SKEW ADJ. (ODD CH.)
REV SKEW ADJ. (ODD CH.)
ODD SKEW ADJUST
EVEN SKEW ADJUST
CHARACTER GATE ADJUST

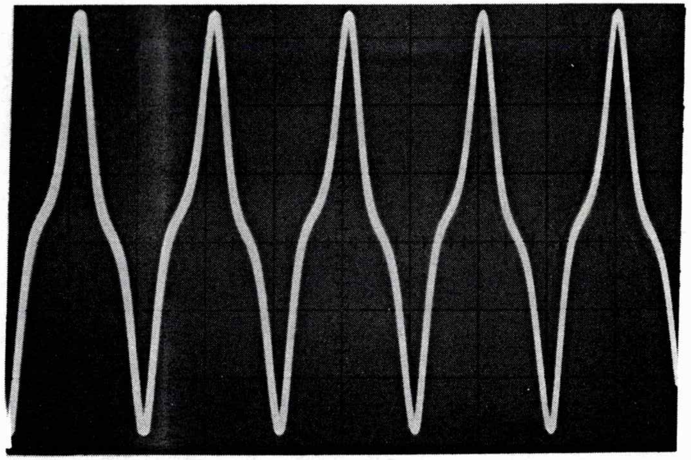
Read Preamp

1. Mount a scratch tape and write all ones at 200 BPI.

2. Scope each preamp output and adjust the output for 6.4 volts peak to peak.

NOTE

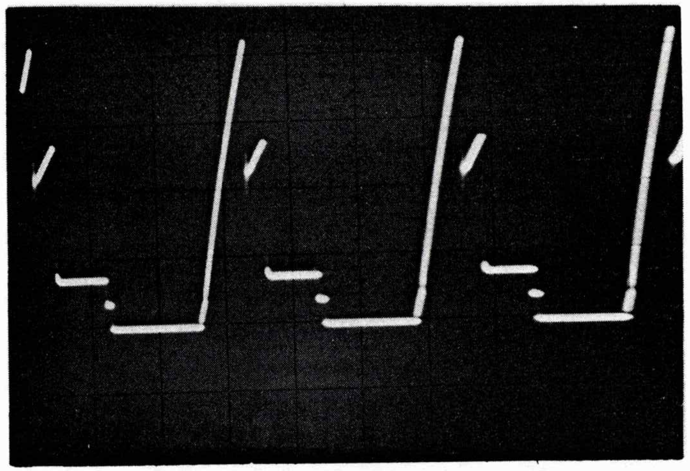
If means for writing 200 BPI are not available, write all ones at 800 BPI and adjust for 5.4 volts peak to peak.



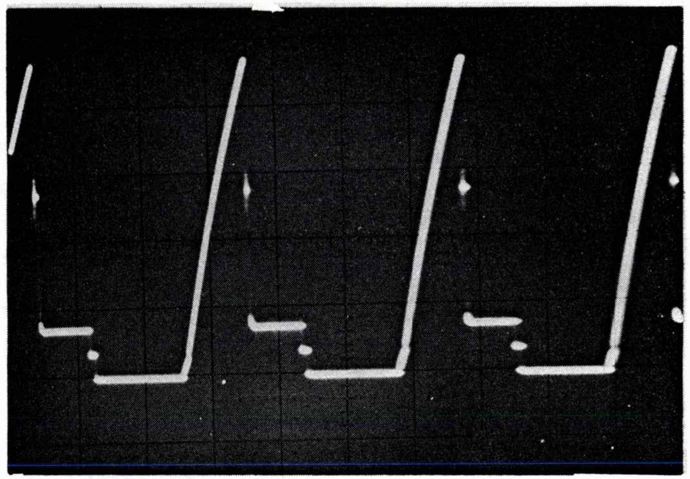
PREAMP GAIN ADJUSTMENT
200 BPI at 25 IPS
VERT = 1 v/cm
HORIZ = 0.2 ms/cm

Read Static Skew

1. Mount the standard skew tape (HP 9162-0027) and provide a forward drive command.
2. Connect the oscilloscope channel A to the skew test point of the center track for reference. Set this channel skew delay potentiometers (forward and reverse) at approximately mid range.
3. Connect the oscilloscope channel B to each skew test point in succession and algebraically add scope channels A and B.
4. Adjust the scope track to display at least one full bit time (leading edge of one bit to the leading edge of the next) with vertical deflection about 2 v/cm.
5. Adjust each channel skew delay potentiometer to maximum amplitude.
6. If all channels will not deskew readjust the reference channel and repeat steps 1 thru 5.
7. Perform steps 1 through 7 while moving tape in the reverse direction for reverse skew.



READ SKEW ADJUSTMENT
POOR ALIGNMENT



READ SKEW ADJUSTMENT
GOOD ALIGNMENT

Read Character Gate

1. Mount the standard skew tape (or any "all ones" 800 BPI tape) and provide a forward read command.
2. Connect the oscilloscope channel A to the NOR test point, on the read control board, sync negative and set the horizontal sweep such that 1 bit time equals full scale deflection.
3. Using the gate potentiometer, adjust the low portion of the waveform for 40% of full scale deflection.

Write Skew Delay

1. Load a scratch tape and write all ones at 800 BPI in all tracks.
2. Connect the oscilloscope to the READ skew channels the same as done in the read skew procedure.
3. Adjust each WRITE skew potentiometer for maximum amplitude while scoping the corresponding read channel.

CAUTION

Under no circumstances should any of the read adjustments be altered during the write skew adjustment procedure.

7970 TAPE UNIT TEST BOARD OPERATION

	13191A CONTROL & STATUS TEST BOARD								13192A WRITE		13193A READ BOARD			
	CH (CMND HIGH)	CRW/SET-CRW	WSW	CR (CMND REV)	CF (CMND FWD)	PROG/MAN	PCF CONTROL	PCR CONTROL	XTALK/BLOCK	ODD/EVEN	RD BL/OFF	EVEN/ODD	CYCLE/CF	ERROR STOP/ NORMAL
FWD (STEADY SYNC)	DWN	*1	DWN	DWN	UP	DWN	N/A	N/A						
REV (STEADY SYNC)	DWN	*1	DWN	UP	DWN	DWN	N/A	N/A						
HIGH SPEED FWD	UP	*1	DWN	DWN	UP	DWN	N/A	N/A						
HIGH SPEED REV	UP	*1	DWN	UP	DWN	DWN	N/A	N/A						
FWD START/STOP	DWN	*1	DWN	DWN	UP	UP	VARI	N/A						
REV START/STOP	DWN	*1	DWN	UP	DWN	UP	N/A	VARI						
BI-DIRECTIONAL	DWN	*1	DWN	UP	UP	UP	VARI	VARI						
REWIND	N/A	CRW	N/A	N/A	N/A	N/A	N/A	N/A						
SEARCH EOT (SYNC)	DWN	CTR	DWN	DWN	UP	*2	*2	N/A						
SEARCH EOT (H'S')	UP	CTR	DWN	DWN	UP	DWN	N/A	N/A						
WRITE DATA (STEADY)	DWN	*1	UP	DWN	UP	DWN	N/A	N/A	X'TLK	*3				
WRITE DATA (BLOCK)	DWN	*1	UP	DWN	UP	UP	*2	N/A	BLK	*3				
READ AFTER WRITE **	DWN	*1	UP	DWN	** UP	UP	** *2	N/A	BLK	*3	** RDBL	*3	CF	NORM
READ DATA	DWN	*1	DWN	DWN	DWN	N/A	N/A	N/A	N/A	N/A	*4 RDBL	*3	*5	*6

** NOTE **

THE READ AFTER WRITE OPERATION SET-UP IS SEQUENCE SENSITIVE AND SHOULD BE PERFORMED AS FOLLOWS:

1. Initially set all controls as shown in the chart except:
   a. PCF – FULLY CCW
   b. CF – DWN
   c. RDBL/OFF – OFF (RIGHT)
2. Place RD BL/OFF switch in the RD BL position. (START TAPE MOTION).
3. Place CF switch up.
4. Turn the PCF potentiometer C.W. until start-stop action occurs.
5. To stop read after write test, perform the above steps in reverse order.

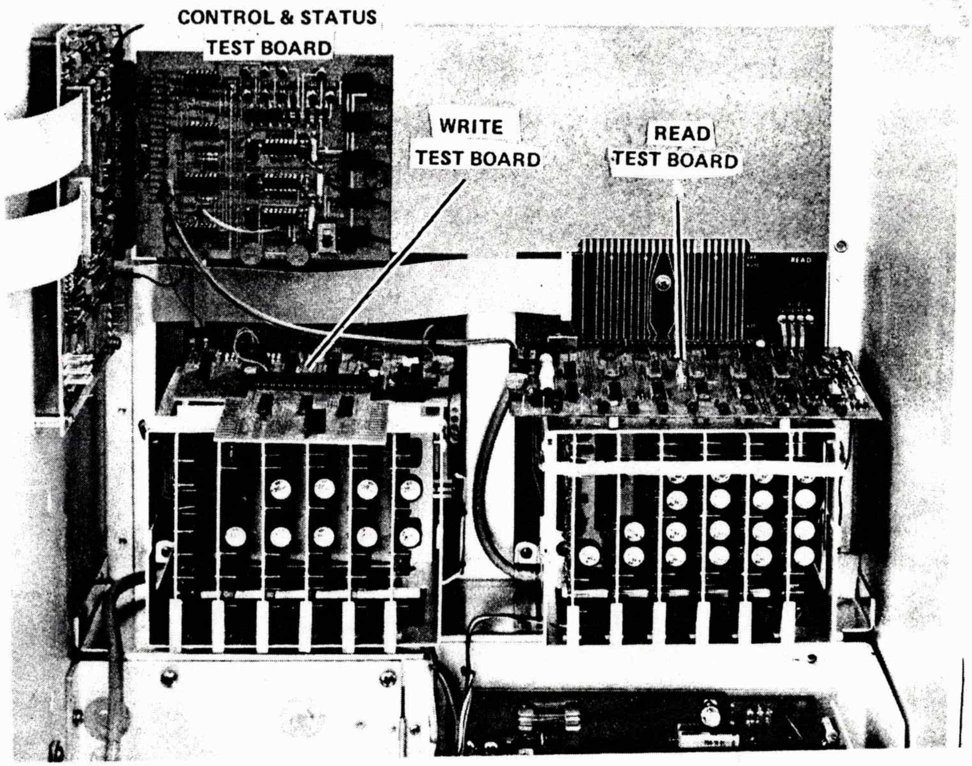
NOTES:

1. WITH CRW/SET SWITCH IN THE SET CRW POSITION, UNIT WILL AUTO REWIND AT EOT – IN CENTER POSITION UNIT WILL STOP AT EOT.
2. WITH PROG/MAN SWITCH IN PROG POSITION, DRIVE TIME IS DETERMINED BY THE SETTING OF PCF OR PCR.
3. PARITY SELECTED BY OPERATOR.
4. START TAPE MOTION WHEN THE SLIDE SWITCH IS IN RD BL POSITION. (TAPE MOTION CONTROL OF RD. BOARD).
5. CYCLE POSITION CAUSES PRECEDING BLOCK TO BE CYCLED.
6. MUST BE IN NORM POSITION WHEN WRITING. (ALSO RESETS ERROR INDICATIONS.)

TEST BOARDS INSTALLATION PROCEDURE

CONTROL AND STATUS TEST BOARD (13191A)

1. Install in the control daisy chain jack.
2. Connect +5 volt jumper to +5 volt pin on the motion control board.
3. Connect the select jumper (GND) to the desired C.S. (CMND SELECT) pin.



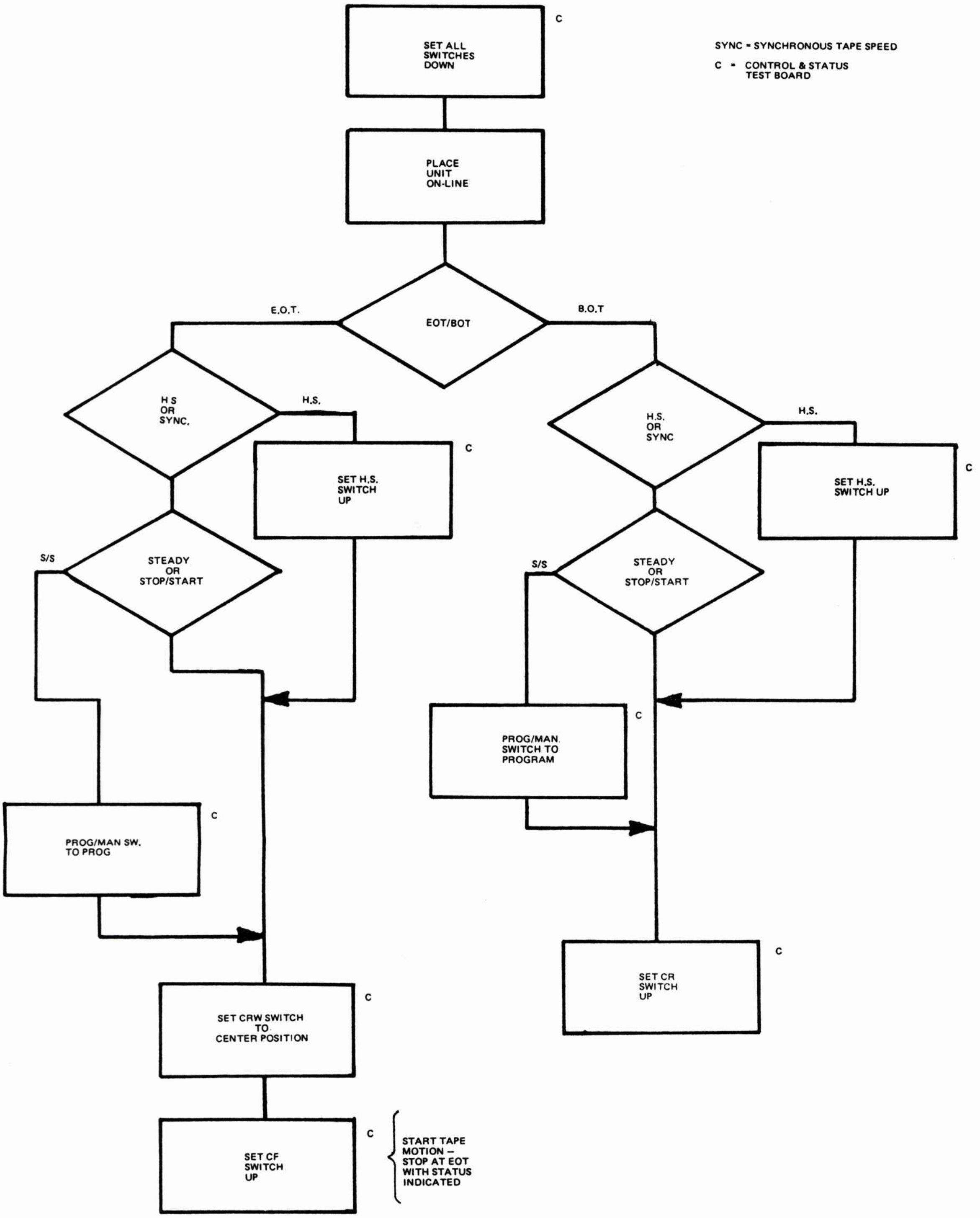
WRITE TEST BOARD (13192A)

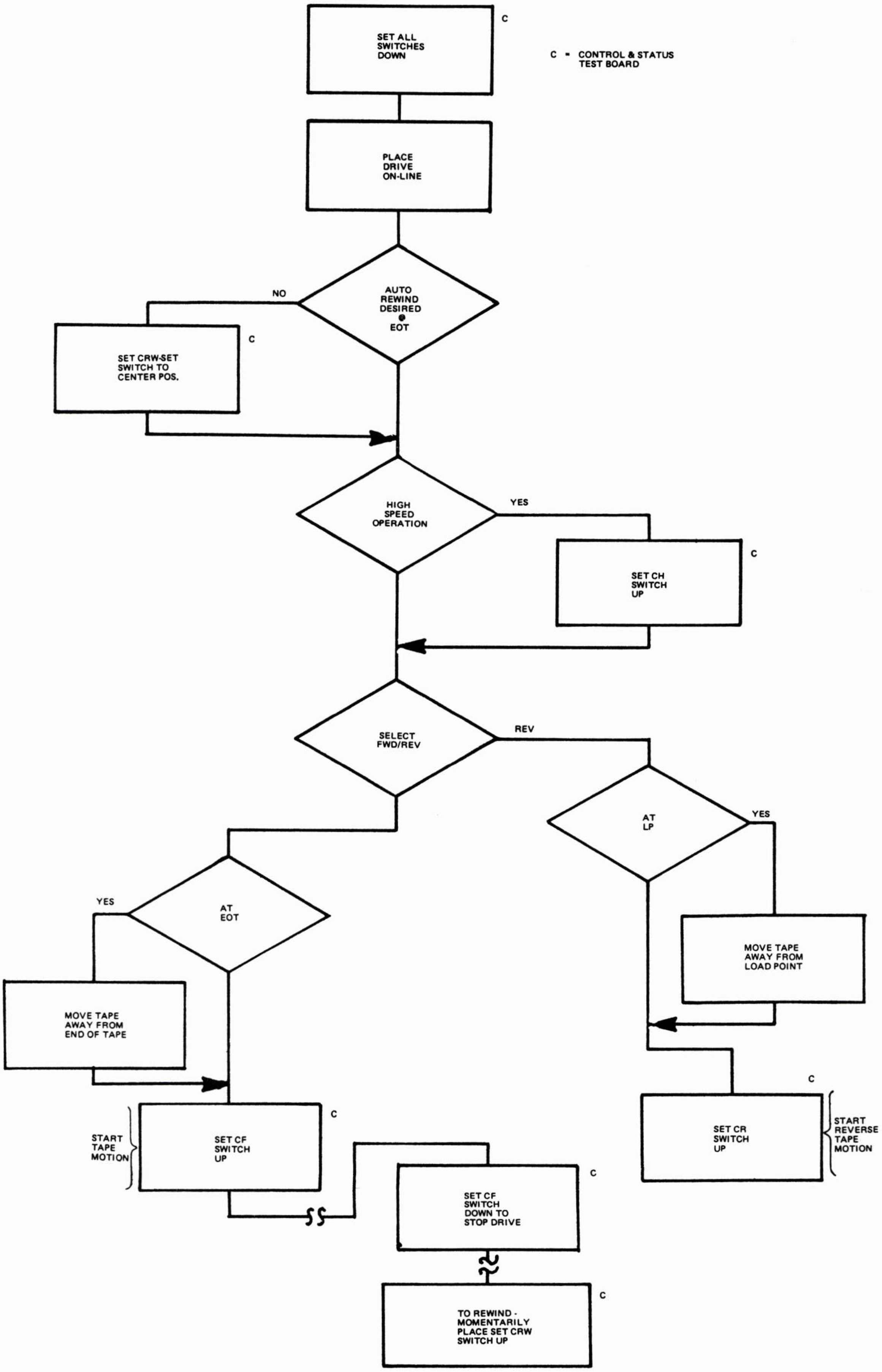
1. Install in the write daisy chain jack.
2. Connect the C.F. (CMND FWD) jumper wire to the CF pin on the control and status test board.
3. Connect power plug to WJ12 on the write mother board.
4. Operate the control/status test board with the write board and write steady data.
5. Monitor W.C. (write clock) test point and adjust potentiometer for proper clock rate.

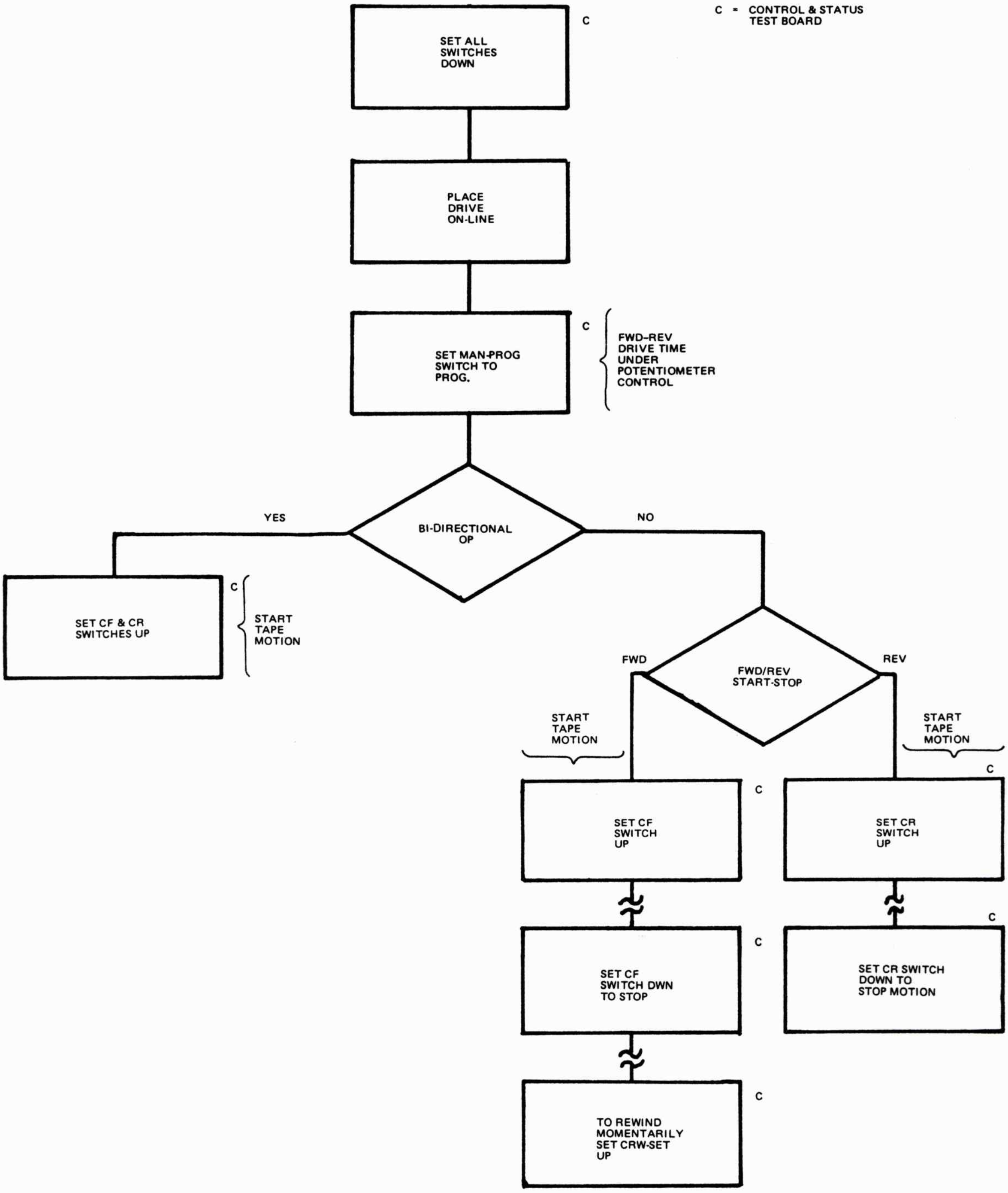
READ TEST BOARD (13193A)

1. Install in the read daisy chain jack.
2. Connect the voltage plug to RJ12 on the read mother board.
3. Connect the 3 control leads to the motion control board.
   *Read——————CR (cmnd rev) test pin.
   *Short blue—CF (cmnd fwd) test pin.
   *Long blue—R/W test pin (connects to U7 pin 4)
4. Operate test boards in read after write mode and monitor 10CL (10 clocks) test point. Adjust clock potentiometer for negative pulse signal to 10 clock times. (800 BPI at 25 IPS -- 10 CL = 500 microsec).

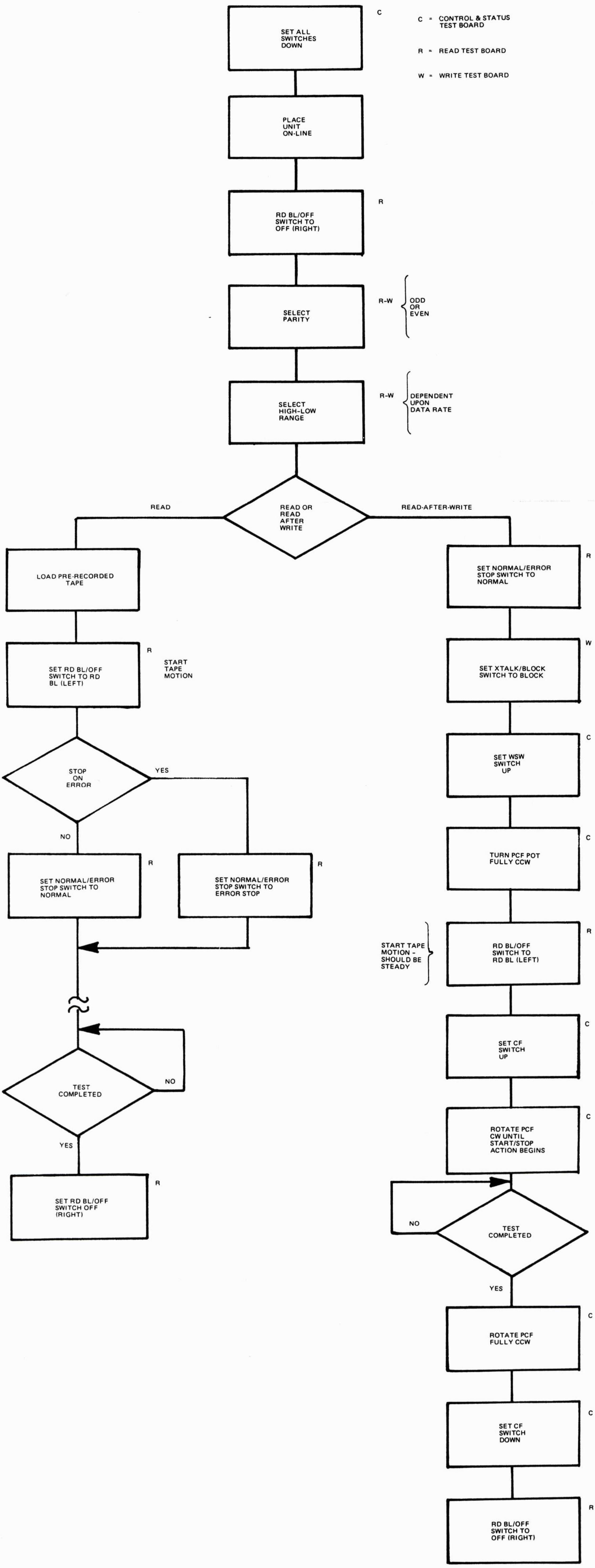
EOT/BOT SE[illegible]H

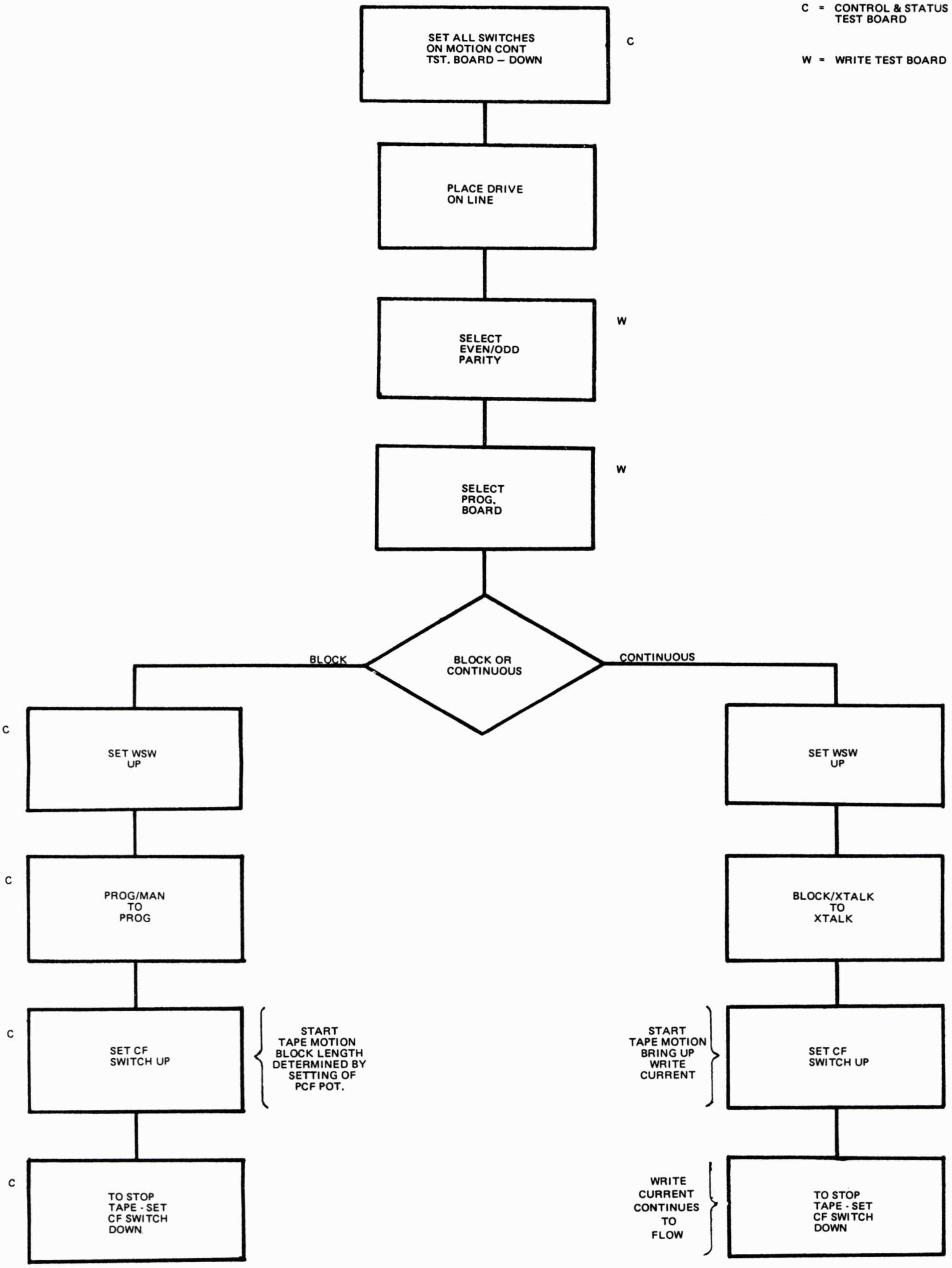

SYNC = SYNCHRONOUS TAPE SPEED
C = CONTROL & STATUS TEST BOARD
SET ALL SWITCHES DOWN
C
PLACE UNIT ON-LINE
EOT/BOT
E.O.T.
B.O.T
H S OR SYNC.
H.S.
SET H.S. SWITCH UP
C
STEADY OR STOP/START
S/S
PROG/MAN SW. TO PROG
C
SET CRW SWITCH TO CENTER POSITION
C
SET CF SWITCH UP
C
START TAPE MOTION – STOP AT EOT WITH STATUS INDICATED
H.S. OR SYNC
H.S.
SET H.S. SWITCH UP
C
STEADY OR STOP/START
S/S
PROG/MAN. SWITCH TO PROGRAM
C
SET CR SWITCH UP
C


C = CONTROL & STATUS TEST BOARD
SET ALL SWITCHES DOWN
C
PLACE DRIVE ON-LINE
AUTO REWIND DESIRED @ EOT
NO
SET CRW-SET SWITCH TO CENTER POS.
C
HIGH SPEED OPERATION
YES
SET CH SWITCH UP
C
SELECT FWD/REV
REV
AT LP
YES
MOVE TAPE AWAY FROM LOAD POINT
AT EOT
YES
MOVE TAPE AWAY FROM END OF TAPE
START TAPE MOTION
SET CF SWITCH UP
C
SET CR SWITCH UP
C
START REVERSE TAPE MOTION
SET CF SWITCH DOWN TO STOP DRIVE
C
TO REWIND - MOMENTARILY PLACE SET CRW SWITCH UP
C

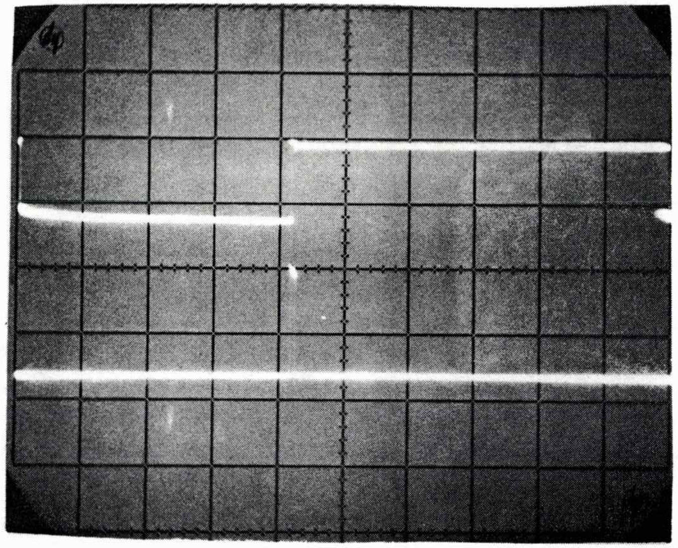

C = CONTROL & STATUS TEST BOARD
SET ALL SWITCHES DOWN
C
PLACE DRIVE ON-LINE
SET MAN-PROG SWITCH TO PROG.
C
FWD-REV DRIVE TIME UNDER POTENTIOMETER CONTROL
BI-DIRECTIONAL OP
YES
NO
SET CF & CR SWITCHES UP
C
START TAPE MOTION
FWD/REV START-STOP
FWD
REV
START TAPE MOTION
START TAPE MOTION
SET CF SWITCH UP
C
SET CR SWITCH UP
C
SET CF SWITCH DWN TO STOP
C
SET CR SWITCH DOWN TO STOP MOTION
C
TO REWIND MOMENTARILY SET CRW-SET UP
C

READ OR READ AFTER WRITE OPERATIONS




C = CONTROL & STATUS TEST BOARD
W = WRITE TEST BOARD
SET ALL SWITCHES ON MOTION CONT TST. BOARD – DOWN
C
PLACE DRIVE ON LINE
SELECT EVEN/ODD PARITY
W
SELECT PROG. BOARD
W
BLOCK OR CONTINUOUS
BLOCK
CONTINUOUS
SET WSW UP
C
PROG/MAN TO PROG
C
SET CF SWITCH UP
C
START TAPE MOTION BLOCK LENGTH DETERMINED BY SETTING OF PCF POT.
TO STOP TAPE - SET CF SWITCH DOWN
C
SET WSW UP
C
BLOCK/XTALK TO XTALK
W
START TAPE MOTION BRING UP WRITE CURRENT
SET CF SWITCH UP
C
WRITE CURRENT CONTINUES TO FLOW
TO STOP TAPE - SET CF SWITCH DOWN
C

SCOPE TRACES



DESCRIPTION A

UPPER TRACE

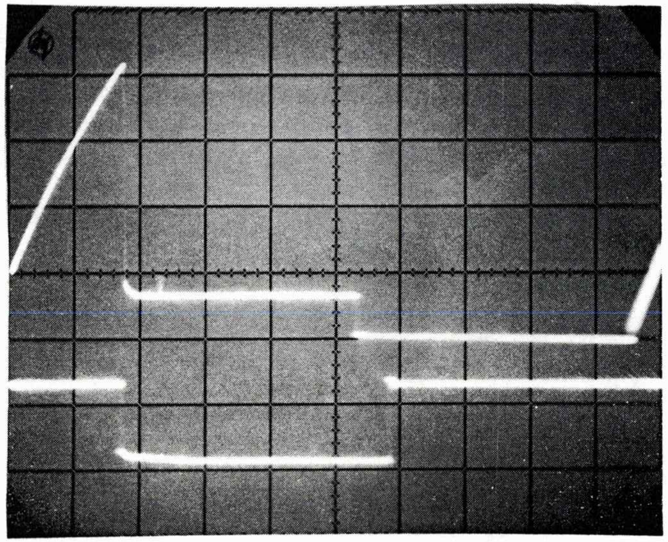
NOR TEST POINT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	1 V/CM

LOWER TRACE

STROBE

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	1 V/CM



DESCRIPTION B

UPPER TRACE

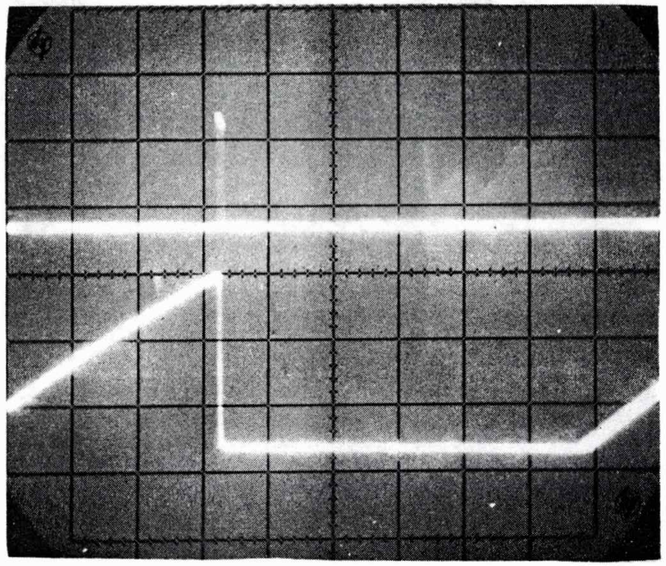
SKEW TEST POINT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	1 V/CM

LOWER TRACE

NOR TEST POINT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	1 V/CM



DESCRIPTION A

UPPER TRACE

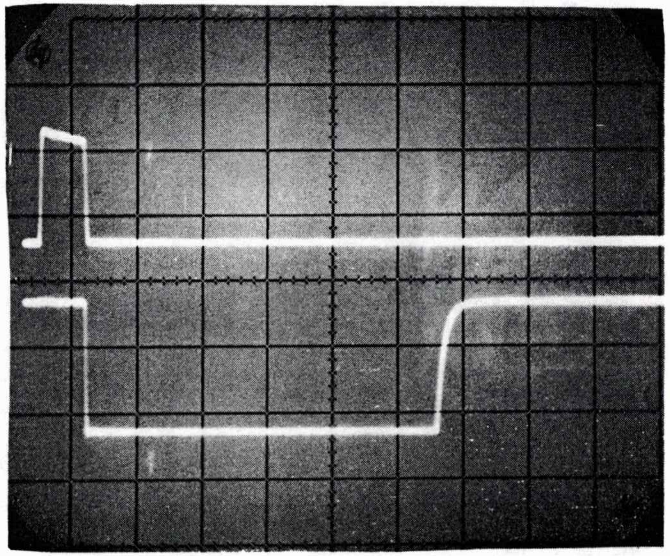
STROBE TEST POINT

HORIZONTAL	10 MICRO SEC/CM
VERTICAL	2 V/CM

LOWER TRACE

CHARACTER GATE TEST POINT

HORIZONTAL	10 MICRO SEC/CM
VERTICAL	1 V/CM



DESCRIPTION B

UPPER TRACE

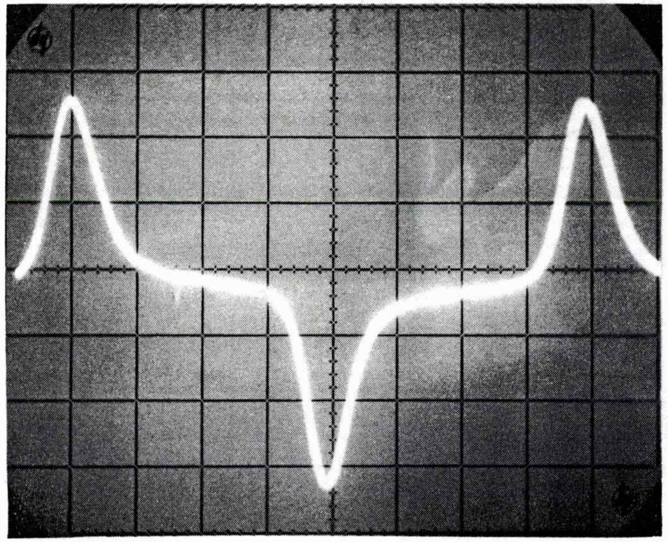
STROBE TEST POINT

HORIZONTAL	0.5 MICRO SEC/CM
VERTICAL	1 V/CM

LOWER TRACE

READ CLOCK

HORIZONTAL	0.5 MICRO SEC/CM
VERTICAL	1 V/CM

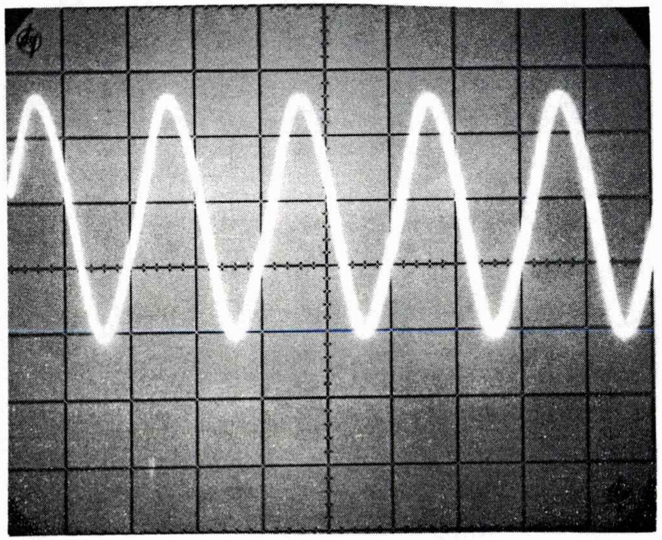


DESCRIPTION A

READ PREAMP - READ AFTER WRITE
200 BPI

HORIZONTAL 50 MICRO SEC/CM

VERTICAL 1 V/CM

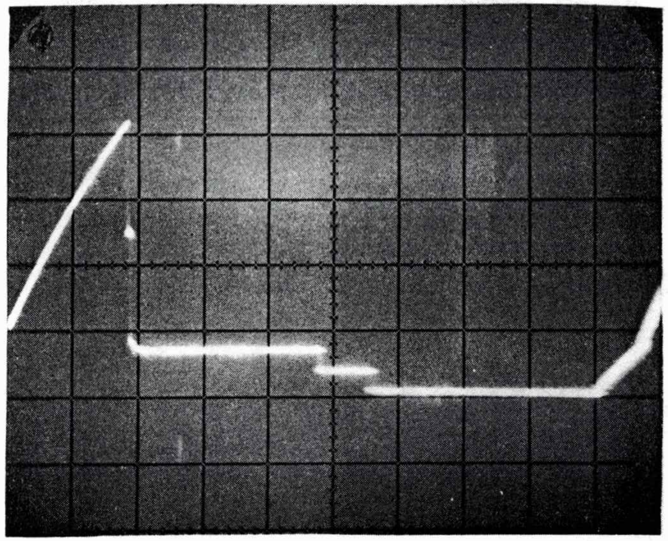


DESCRIPTION B

READ PREAMP - READ AFTER WRITE
800 BPI

HORIZONTAL 50 MICRO SEC/CM

VERTICAL 1 V/CM

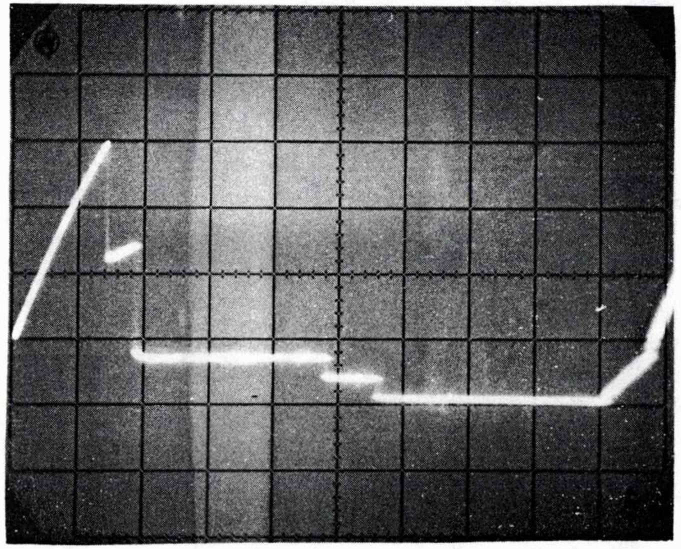


DESCRIPTION A

READ SKEW - GOOD ALIGNMENT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	2 V/CM

ALGEBRAICALLY ADD CHANNEL A TO B.

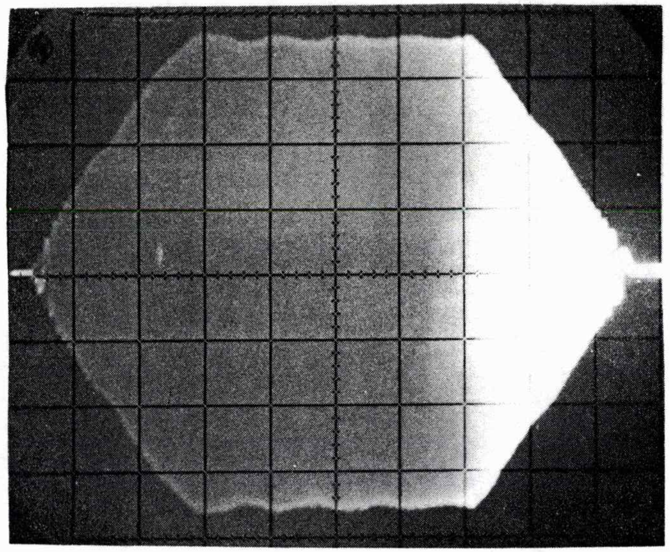


DESCRIPTION B

READ SKEW - POOR ALIGNMENT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	2 V/CM

ALGEBRAICALLY ADD CHANNEL A TO B.

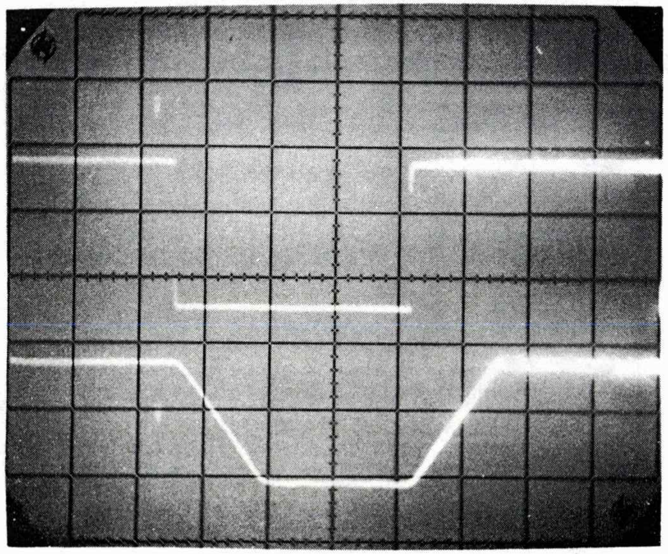


DESCRIPTION A

DATA ENVELOPE

HORIZONTAL - 5 MSEC/CM

SYNC - FWD DRIVE COMMAND TRUE
FOR 34 MILLISECONDS



DESCRIPTION B

UPPER TRACE

FWD DRIVE COMMAND

HORIZONTAL 10 MICRO SEC/CM

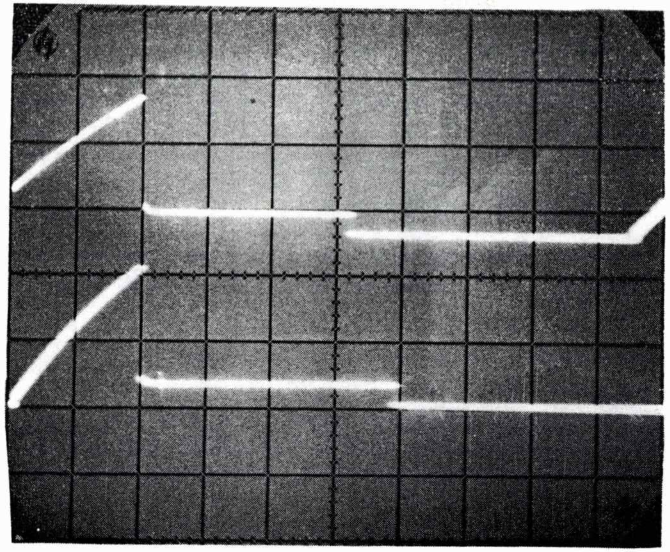
VERTICAL 2 V/CM

LOWER TRACE

TACH. TEST POINT

HORIZONTAL 10 MICRO SEC/CM

VERTICAL 0.5 V/CM



DESCRIPTION A

UPPER TRACE

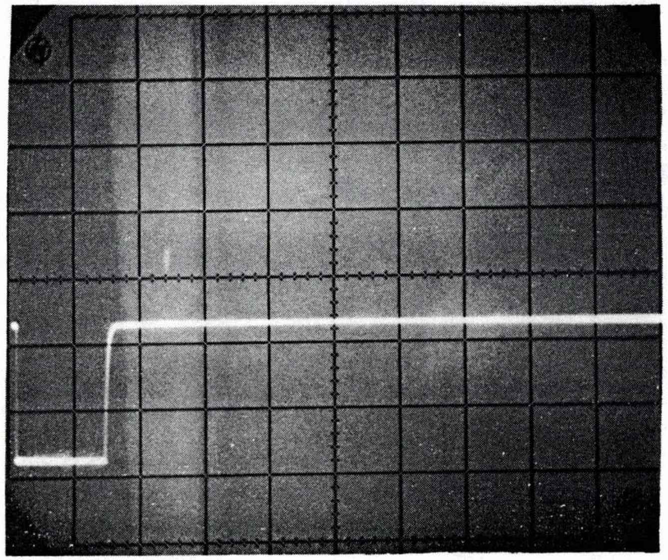
SKEW CHANNEL 2

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	2 V/CM

LOWER TRACE

SKEW CHANNEL P

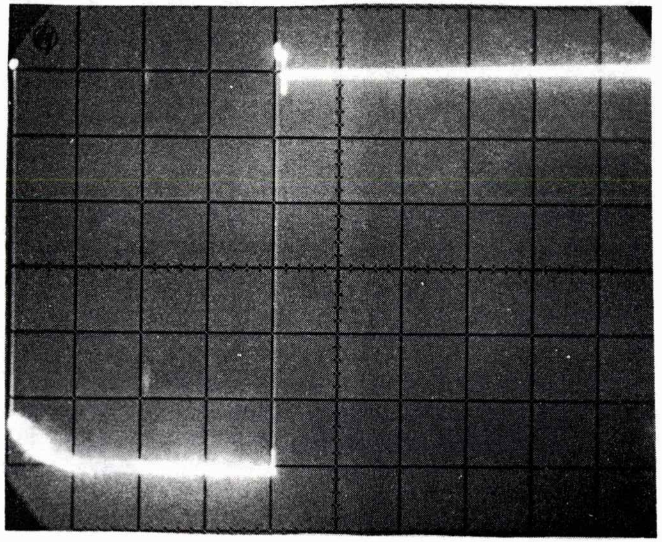
HORIZONTAL	5 MICRO SEC/CM
VERTICAL	2 V/CM



DESCRIPTION B

READ CLOCK

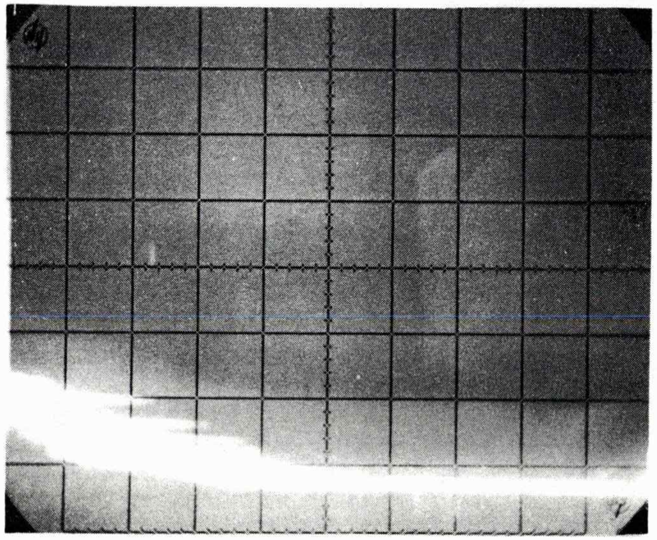
HORIZONTAL	2 MICRO SEC/CM
VERTICAL	2 V/CM



DESCRIPTION A

NOR TEST POINT

HORIZONTAL	5 MICRO SEC/CM
VERTICAL	0.1 V/CM



DESCRIPTION B

NOR TEST POINT

HORIZONTAL	1 MICRO SEC/CM
VERTICAL	0.2 V/CM

DIGITAL MAGNETIC TAPE MANUFACTURING

DIGITAL MAGNETIC TAPE MANUFACTURING

INTRODUCTION

Producing a computer grade tape which functions smoothly and efficiently, pass after pass, is a difficult task demanding a high degree of technology and quality control. Computer tapes must be capable of storing data at extremely high densities and be physically durable.

Magnetic tape is actually comprised of three components - - the oxide, which is the magnetic material; and the binder, which holds the oxide to the backing.

OXIDE

Early oxide materials presented some problems because of instability. It was not only difficult to erase but would actually rust. Present day refinement has produced oxides of uniform particle sizes and stable magnetic qualities.

BACKING

The backing material has two main functions - - supporting the oxide and isolating the adjacent layers of oxide while it's on the reel. The backing must have a high degree of dimensional stability as well as being flexible and physically durable. Materials used must be manufactured to tight thickness tolerances over long lengths with extremely smooth surfaces resistant to wrinkling or physical distortion.

Original backings were paper, then acetate. Now polyester has become the most widely used material because of its increased strength and durability. Polyester is also less sensitive than other backings to changes of temperature and humidity. It has high tensile strength and an elastic memory which makes it ideal for the high speed, start-stop activity of computer applications.

BINDER

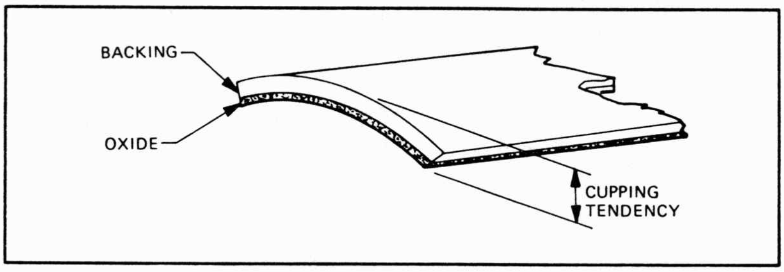
Binders or adhesives are actually composed of many ingredients, all chosen specifically to ensure proper performance. These ingredients include a wetting agent, a lubricant, and a conductive element.

The wetting agent reduces surface tension of the oxide/binder mixture. This prevents the formation of lumps in the coating. The lubricants assure that the coating runs smoothly over the head. This lubricant extends throughout the oxide coating which prevents it from being worn away. This is an obvious benefit to the user since it greatly increases head and tape life.

The conductive element is added to electrically drain any static properties. Some tape manufacturers add a conductive element to both sides of the backing to further reduce static charges.

To assure coating perfection, the binder must flow smoothly to permit even application, have a controlled drying time to prevent the forming of clumps or agglomerates and be able to supply a durable and flexible bond between the oxide particles and backing.

Compatibility between the binder and backing is an important consideration. The coefficient of expansion of the binder and backing must be the same. If this is not true, the tape will tend to cup or curl as temperature and humidity change.



CLEANLINESS

Lint, dust and dirt are the worst enemies of computer tape. These tiny specks of contamination on the tape surface will disrupt the intimate contact between the tape and the heads and greatly reduce the amount of signal transfer. Consequently, all tape manufacturing plants are specially designed to maintain the cleanliness necessary for coating magnetic tape. Positive air pressure moves atmospheric contaminants away from critical areas. During the actual coating and drying process, the emphasis on cleanliness is greater than hospital operating rooms. Most tape manufacturing plants provide special air lock doors that keep unsettled dust from entering the coating area. Specially designed units heat and filter the air used in the drying ovens. All efforts are toward keeping the tape completely free of any defect that might be caused by airborne contamination.

DISPERSION

The process of mixing the oxide and binder is a critical procedure. The mixture must be exact and complete. This process is called milling. If milling is insufficient, the coating will be rough and uneven. If it is excessive, the microscopic oxide particles may be broken, imparing their recording properties. Once the milling is complete, the dispersion (mixture of oxide and binding) is ready to be applied to the backing. The backing is taken from a large roll and coated with the oxide. After being coated, solvents (part of the binder) are driven off and the coating is dried. Although the process sounds simple, it is probably the most precise step in the manufacturing procedure.

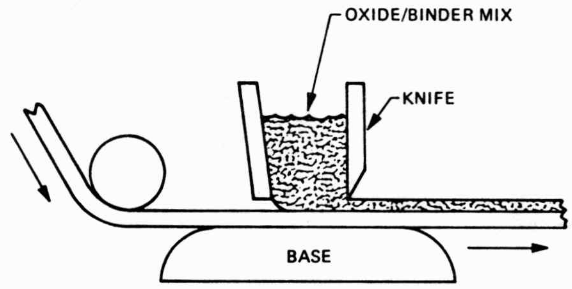
COATING

Coating precision controls three of the four factors which govern the output that can be expected from a tape. Magnetic properties of the oxide used in the dispersion are, of course, the most dominant factor; <u>but</u>, surface smoothness, uniformity of coating thickness and orientation of the oxide particles within the coating also are vitally important. Uniformity in coating thickness is an important factor in maintaining uniformity in output.

The three most common coating methods are knife, gravure, and reverse roll method. The exact technique of coating is a highly guarded secret by manufacturers.

Knife Coating Method

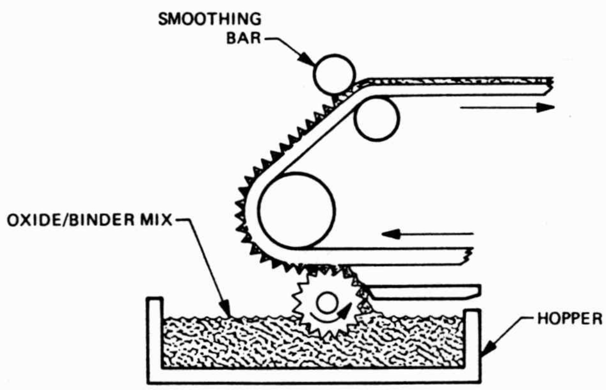
The most common form of coating is knife coating. The blade of the "knife" extends across the backing forming a dam to contain the oxide/binder mix. The small gap between the bottom of the knife and the backing meters the coating thickness. The mix viscosity and coating speed also tend to determine this coating thickness. The knife may be fixed so that the gap between the knife and base through which the backing and coating pass is constant, or the gap may be maintained at a constant distance above the backing surface. When the gap is referenced to the base, variations in the backing will produce variations in the coating thickness. To lessen this problem, the knife may be referenced to the backing surface.



KNIFE COATING METHOD

Gravure Coating Method

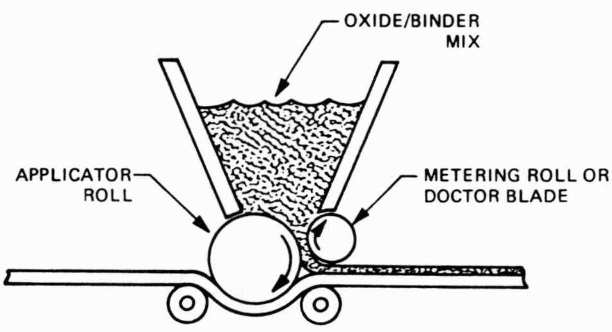
The surface of the gravure roll is engraved with a series of fine, closely spaced grooves. The grooves pick up and hold the mix. Excess is removed from the surface of the roll so that the only material left is that contained in the grooves. Thus, the metering action is produced by the size, shape and pitch of the grooves rather than the spacing between the two rolls. The mix is transferred to the backing in the form of small ridges across the backing. A smoothing roll changes these ridges to a uniform coating. This smoothing action is the major shortcoming of the gravure method.



GRAVURE METHOD

Reverse Roll Method

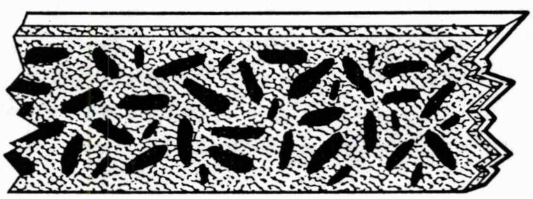
Metering action of the mix is independent of the backing thickness. The mix is applied to a very accurate, smooth-surfaced applicator roll. The layer of mix is carried around the roll, then metered either by a metering roll or "doctor" blade similar to that used in the knife coating method. The metered mix is then transferred from the applicator to the backing. Thus, the coating is applied in a wiping action. Although this technique reduces coating thickness variations, it does not eliminate all variations. The size of the metering gap may vary due to imperfections in bearings or doctoring knife. Here, as always, viscosity and coating speed play an important part in coating accuracy.

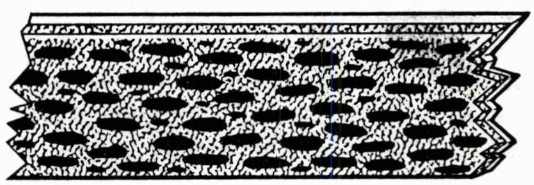


REVERSE ROLL METHOD

PARTICLE ORIENTATION

Orientation of the oxide particles is important because it makes the particles more susceptible to being magnetized. Randomly oriented particles are not as magnetically inclined as those oriented in the direction of recording.

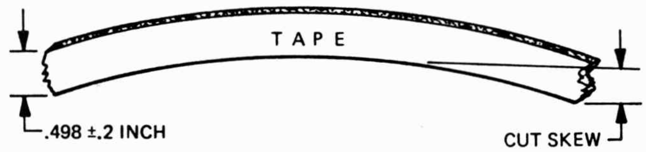

RANDOM ORIENTATION OF IRON OXIDE PARTICLES


ORIENTATED IRON OXIDE PARTICLES (MOLECULES WITHIN THE OXIDE PARTICLES ARE ORIENTATED TO STORE DATA)

Early manufacturing applied the oxide as smoothly as possible but with no regard to the relationship of one oxide particle to another. Now, by passing the tape through a powerful magnetic field while the coating is still liquid, the particles are aligned in one direction. Once the coating has been dried, the particles can never change alignment. Orientation increases output and also results in a better signal to noise ratio.

TAPE SLITTING

Slitting is done with large rotary knives. These knives must be perfectly aligned to assure clean, straight edges. The slitting operation must provide tape strands that are clean and straight for distances of as much as two miles. Width tolerances are normally held within a range of plus or minus two mils. These near perfect edges are extremely important. Bad edges may impare tracking, disrupt the head to tape contact and cause errors in the outside tracks.



CUT SKEW

The final step is winding tape on reels and exposing them to a powerful electro-magnetic field. This is to erase any magnetic signal that may have been picked up during manufacture. The tape is then packaged in a water tight, dust free plastic container for shipment.

DIGITAL COMPUTER TAPE HANDLING AND STORAGE

DIGITAL COMPUTER TAPE HANDLING AND STORAGE

INTRODUCTION

As increasing quantities of the world's recrods are being kept on magnetic computer tape, there is a growing concern about the permanence and recoverability of these vital facts that are invisibly stored on a plastic ribbon.

The preservation of both operating and historical files is the primary concern. But another factor, of economic importance, is the prevention of damage to the recording tape so that maximum use may be obtained from every reel of tape.

If stored information is unrecoverable because of either lack of safeguards by operating personnel or major catastrophe during storage, the result could be anything from temporary inconvenience to complete business collapse. Also, if reels of tape are failing and being retired long before their normal life expectancy, operating expense is increased.

Modern magnetic tape coatings have the ability to retain the intelligence placed on them during the recording process for an infinite amount of time. The recorded information does not tend to fade or weaken with age. It is essentially permanent and will remain unchanged until actually altered by an external magnetic field. Although the magnetic data recorded on tape will not deteriorate, physical damage to the tape will greatly effect performance. It is therefore important that tape be stored and handled in a manner that will make it physically possible to recover the recorded information.

WORK AREA

The location in which the tape is actually used should approach, as closely as is practicable, a "clean-room" environment characterized by the absence of normally expected airborne dust and lint. Whenever possible, maintain the room air pressure at a somewhat higher level than the surrounding area. This positive internal pressure will decrease dust infiltration through door and windows.

Variations of temperature should be held to within ±5° F of a preselected value, and the relative humidity should be kept constant to within ±10 percent. Generally, an environment that is comfortable for personnel is also ideal for tape. In broad terms, this would be a temperature in the 70's and a relative humidity of about 40 percent.

Food and drink should be prohibited in the work area. Food particles can easily be deposited on the tape or tape unit from the operators hands. A drink spilled in the wrong place will contaminate not only the tape but possible the entire room. Smoking in the work area should also be prohibited. Although smoke will not generally contaminate tape, ashes are frequently the cause of tape problems.

PERIODIC CLEANING

The work area should be maintained by periodic cleaning of shelves and floors. There are liquid cleaners available for this purpose that leave no residue. Floors should not be waxed because foot traffic abrades the wax causing fine dust that could contaminate the entire room. It is generally considered good practice to clean a storage cannister before bringing it into the work area. This prevents dust that has accumulated during storage from being transported to the work area.

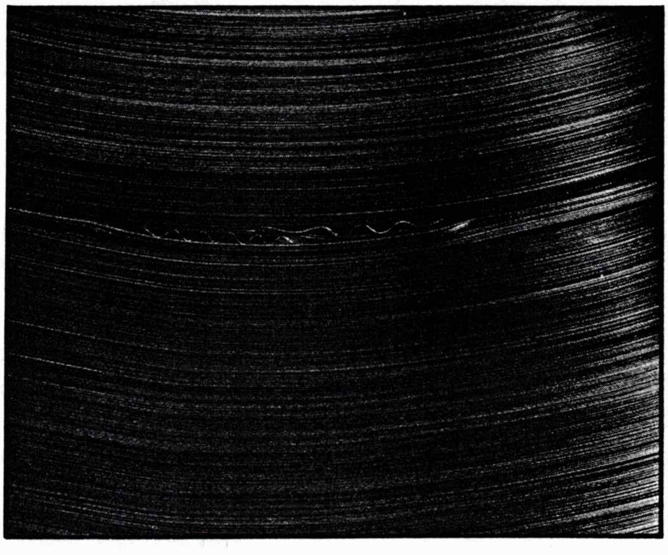
PLASTIC RING OR COLLAR

In the interest of storing more tape in a given area (thus reducing storage cost per unit) some users have chosen a plastic ring or collar device that wraps around the outer diameter of the reel. This allows the reel to be hund in the storage facility without the use of a standard cannister. While this device will suffice in many applications, one should realize that its use constitutes a tradeoff. Additional space is gained for storage, but the reel is being supported by the flanges and not the hub. The plastic ring or collar may seal well enough to prevent dust from settling on the tape during storage, but the outer surface of both flanges is vulnerable to dust accumulation. With the introduction of the slim-line type of cannister, additional storage space can be gained without sacrificing the benefits of a closed container. For this reason, it is the preferred container. If the tape is stored using collars, care must be exercised when removing or replacing the reel as it is easy to inadvertently squeeze the reel flanges during this operation.

PREPARATION FOR STORAGE

Preparing tapes for storage is as important as the storage area. Most important is the way tape is wound on the reel. Poor winding can result in distortion of the tapes' backing. Generally speaking, it is best to use low winding tension. High pressures within the roll could permanently distort the polyester backing. Backing distortion caused by extreme pressures within the tape reel may result if a roll of tape is wound too tightly and then subjected to an increase in temperature while in storage.

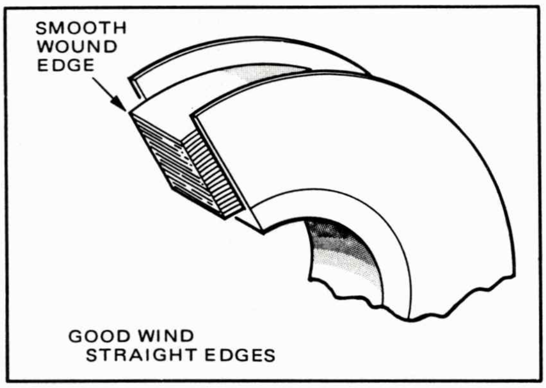
Problems are also possible if the tape tension is too low. If the wind is too loose, slippage can occur between the tape layers on the reel. This "cinching," as it is called, can distort the tape by causing a series of creases or folds in the area that has slipped.

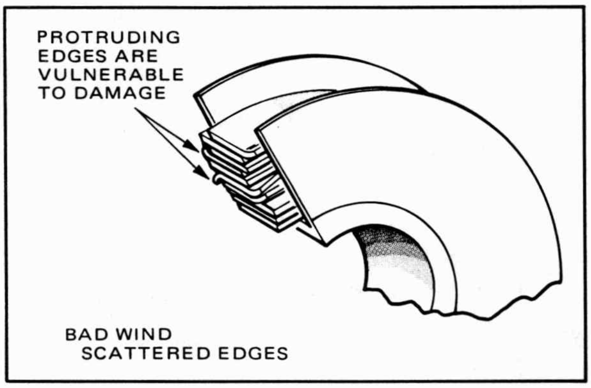


CINCHED TAPE

Along with proper tension, another important consideration is wind "quality." The successive layers of tape should be placed on the reel so that they form a smooth wind with no individual tape strands exposed. A smooth wind offers the advantage of build-in edge protection.

A scattered wind will allow individual tape edges to protrude above the others. Since there is no support for these exposed strands, they are vulnerable to damage.



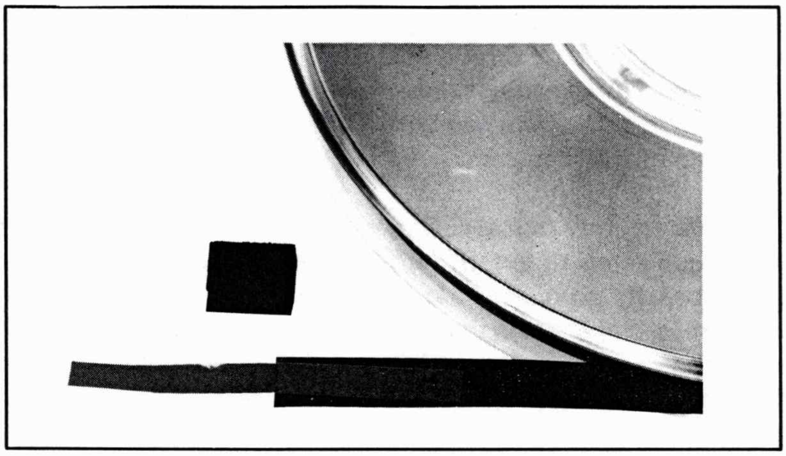


It is sometimes suggested that tapes in storage be rewound at specific intervals such as every six to 12 months to relieve internal pressures. This would be recommended for tapes of marginal quality or for those with other than heavy duty binder systems.

WHEN SHIPPING TAPES . . . .

Logically, a first consideration would be the physical protection of the tape while being transported. The outer shipping container, into which the cannisters are placed, must afford the necessary strength and rigidity to protect the tapes from damage caused by dropping or crushing. While a container that is 100 percent watertight would not be necessary, it must nevertheless, provide a reasonable degree of water resistance. It should, for example, be capable of protecting the contents from being damaged if, during shipping, it is left on a loading dock in the rain.

While it is always good practice to secure the free end of the tape on a reel, it is particularly important to do so when preparing tapes for shipping. The combination of a vinyl strip and a sponge seems to function ideally.



SECURE THE FREE END

STRAY MAGNETISM

The bulk degausser is designed to produce maximum external field to erase tape while on the reel. However, if a degausser is held approximately 2.7 inches from the tape the field is diminished to the point that it has no discernable effect. Although tape in shipment might be subjected to sources of magnetic energy such as motors or transformers, it is safe to assume that field strengths sufficient to degauss tape will not be encountered if properly packaged. This is accomplished if the tape is packed with bulk spacing material such as wood or cardboard between the cannisters and the outer shipping container. Normally, three inches of bulk spacing will give adequate protection, and virtually eliminate any potential erasure. This magnetically protective spacing can also be justified because of the excellent protection gained against any physical damage.

Tape in transit may be subjected to temperature extremes. Temperatures as low as -40° might be encountered in the cargo hold of an aircraft. A temperature of 120° F could easily be encountered in a motor vehicle in the summer sun. <u>All incoming tape should be allowed to reach environment equilibrium before being used.</u>

OPERATOR EDUCATION

The tape cannister is probably the cleanest area in the computer center. Thus, tapes should remain in their cannisters until actually placed on the tape unit and should be returned to their cannisters immediately after use. To maintain a clean cannister, its cover should be replaced after the tape has been removed.

Since the hub is the strongest and most stable part of the reel, operators should always handle the reel by the hub and not the flanges. This practice will prevent operators from squeezing the reel flanges together when handling a reel of tape.

It is important to inspect the tape unit visually after each reel of tape is run to determine if cleaning is necessary. If the transport becomes contaminated with dust or wear products from the tape, complete contamination of an entire roll of tape can easily result. Contaminants can collect on heads and guides and be dumped along the backing or coating surface of the tape. This contamination will then be wound into the reel under pressure, causing it to adhere firmly to the surface. Each one of these deposits will appear as a dropout or group of dropouts the next time the tape is used.

Tape contamination caused by finger prints can be reduced by remembering not to touch the tape unnecessarily and can be eliminated through the use of lint-free gloves. Frequent cleaning of the tape unit will reduce the chance of spreading contamination from one reel of tape to others in the library. A cotton swab or lint-free pad moistened with HP head cleaner or similar cleaner is recommended for cleaning all elements of the tape path.

It was previously mentioned that tape should be allowed to come to temperature equilibrium before being used. If tape is subjected to extremely low temperature and used before it returns to normal environmental conditions, it may become physically distorted. When this tape is subjected to the start-stop action in normal use, the individual tape layers can shift due to momentum and result in severe cinching. This can also happen if a carton containing very cold tape is dropped or handled roughly. It is very important that incoming tape be allowed to stabilize for 24 hours before being used. <u>Do not use artifical means to hasten this stabilization period.</u>

EDGE DAMAGE

One of the most serious and more common forms of tape failure is generally categorized as edge damage. Damaged edges can be caused by the reel, tape unit or the operator. A broken or badly distorted reel can quickly damage a tape. The effect of a broken or cracked flange is easily noticed as the tape will exhibit a series of nicks or mutilated areas along one edge; and the cause can be easily detected because of the obvious defect in the reel.

A warped or distorted reel, however, can also cause damage to one or both edges as the tape rubs against the flange when used. A similar type of edge damage may also occur if the transport is misaligned.

Either of these faults can result in complete failure of a roll of tape. An examination of the edges of a tape that has been damaged in this manner will disclose an accumulation of loose polyester fibers and oxide.

It is sometimes difficult to ascertain the cause of edge damage or even to notice its effect until the damage is severe. It is suggested that operators acquire the habit of physically inspecting the transport in the area of the guides and heads for an excessive buildup of oxide or backing debris. This deposit is generally the first clue that something is wrong. Excessive errors on an edge track may also indicate that a physical alignment problem exists.

It is also good practice to observe the physical condition of the tape. A sure sign of developing edge damage would be a lip or distortion on the edge being injured.

It is strongly recommended that operators be constantly on the alert for signs of potential trouble. This can best be accomplished by understanding what to look for and by performing regular periodic inspections of the tape and tape units. It is also suggested that all operators be aware of the following list of do's and dont's. The list was formulated from personal observation of operators at many computer installations.

1. Always handle the reel by the hub; never hold it by the flanges.
2. Never push on the flanges when mounting tapes; always push on the hub.
3. Be careful when laying down a reel.
4. Do not throw tapes around - even in cannisters or wrap-around rings.
5. If a reel is dropped, check it immediately for cracked flanges as it is very likely that damage has occurred. Also, inspect for tape edge damage as soon as possible.
6. Do not twirl tapes in the hand.
7. Do not smoke or eat food in the work area.
8. Slow down if at all possible. Most bad handling practices are a result of haste.
9. Educate all personnel (especially new operators) on proper tape handling procedures.
10. Use common sense.

DIGITAL MAGNETIC CHECK CHARACTERS
NRZI

DIGITAL MAGNETIC TAPE CHECK CHARACTERS

SEVEN/NINE-TRACK CHECK CHARACTERS

The standard nine-track format contains data followed by two check characters, a CRCC and an LRCC.

The seven-track format contains data followed by one check character, an LRCC.

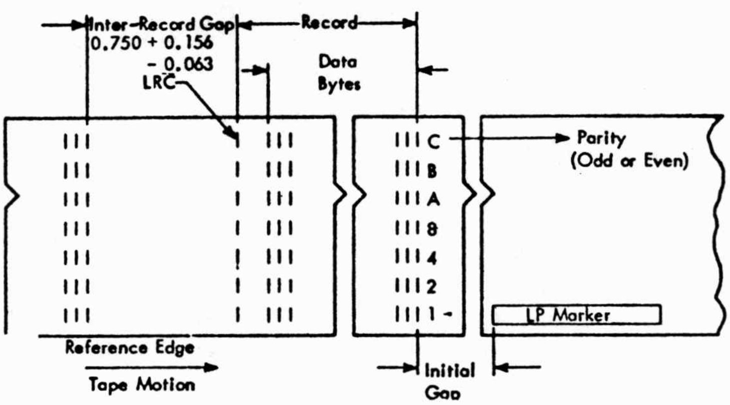
The standard nine-track format writes two check characters at the end of each block. The first check character is the cyclic redundancy check character (CRCC) and the second check character is a longitudinal redundancy check character (LRCC).

The CRCC is a character developed in the CRC register in the tape control. This character, during each nine-track write operation, represents an accumulation of all the bits in the block. Four byte spaces after the last data byte, the CRCC is written on tape.

The second check character (LRCC) is an odd/even parity count of all the bits in each track of a block. The total number of bits in any track of a block is made an even number by placing a 1 or 0 in the LRCC position. The second check character is written four spaces after the CRCC, or a total of eight spaces from the last data byte. The nine-track LRCC represents the same odd-even bit count as the LRCC used in seven-track operation. Since the CRCC is written before the LRCC, the CRCC bits are included in the odd/even LRCC count. Each track must have an even number of bits in each block.

For seven-track operation only one check character (the LRCC) is written.

LRCC in seven-track operation is written four character spaces after the last data character.



SEVEN/NINE-TRACK TAPE MARK

Groups of blocks can be separated by a "tape mark." A tape mark is a one character block with a single check character (LRCC). The bit configuration of a nine-track tape mark is bits 3, 6, and 7 in both the single character block and the LRC character. A seven-track tape mark consists of bits 1, 2, 4, and 8 in both the single character block and the LRC character. Both seven and nine-track tape marks are generally preceded by a gap of erased or blank tape.

Data Byte Parity

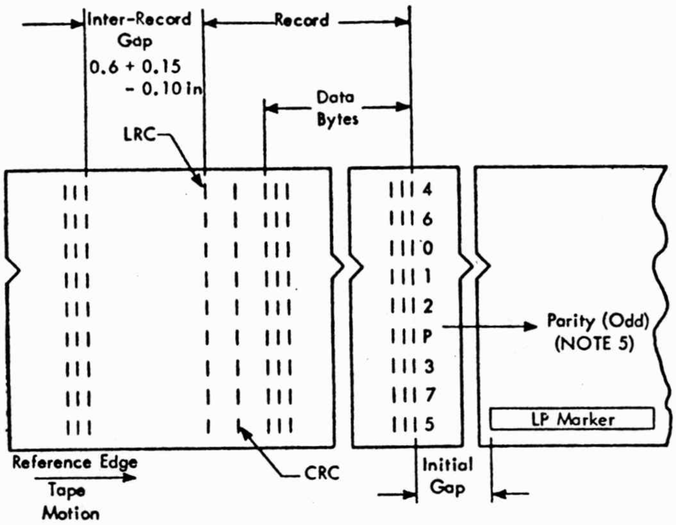
The parity bit, or P bit, of each character is used to detect parity errors. The P position of a character is used to detect parity errors. The P position of a character can contain a 1 or a 0, depending on the number of bits in the rest of the character. A standard nine-track tape uses odd parity; thus, the total number of bits in a character, including the P bit, must be odd. If the data portion (bits 0-7) of a character contains an odd number of bits, the P position should contain 0. If the data portion contains an even number of bits, the P position will be on, to make the total odd. All correct characters have an odd number of bits. If a character with an even number of bits is detected, a lateral parity error has occurred.

CHECK CHARACTER PARITY

- Nine-track LRC character always odd lateral parity due to the generation of the CRCC.
- Seven-track LRC character and nine-track CRC character can be odd or even lateral parity.
- CRC character will contain an odd number of bits if there are an even number of data characters.
- CRC character will contain an even number of bits if there are an odd number of data characters.

During nine-track operations, the LRCC always contains an odd number of bits. Thus, the lateral parity of a nine-track LRCC is always odd. However, the lateral parity (number of bits in the character) of the nine-track CRCC can be an odd or even number. As a general rule, the lateral parity of the CRCC will be an even number if the total number of data characters in the entire block is an odd number. Likewise, if the total amount of data characters in the block is an even number, then the lateral parity of the CRCC will be odd.

A nine-track LRCC will always contain an odd number of bits; the CRCC may be odd or even, depending upon the number of data characters within the block. The seven-track data format may contain either an odd or even number of bits in the LRC character. This is possible because seven-track operations may employ odd or even redundancy when handling data characters.



CYCLIC REDUNDANCY CHECK

- To permit error correction, the tape record contains a cyclic redundancy check character.

To identify which track contains errors, two check characters are written at the end of the record (instead of only one as in former tape systems). The added check character is called a cyclic redundancy check (CRC) character; it is written after the data but before the usual longitudinal redundancy check (LRC) character. The circuit that generates the CRC character is based on a complex equation that makes the mathematical probability of an undetected error almost zero. The mathematical formula used is involved and is of no use in troubleshooting, but it is possible to shift characters into the cyclic redundancy check register one at a time and predict what the results will be after each shift.

The CRC character aids in error detection, but its primary function is determining which track contains the error. When a record is read, a new CRC character is computed and combined with the CRC character from the tape. The result should be a "match pattern," 111010 111 in the CRCR. If the record contains an error, the erroneous CRC value is used to determine the track in error.

PHILOSOPHY OF ERROR CORRECTION

Error correction circuits provide the ability to correct the majority of errors encountered in normal tape operations. Tape control error correction assumes that the data on tape was written correctly and any errors detected are a result of tape damage or read failure. No attempt is made to correct the tape. Correction is performed only on the data sent to the channel interface. Corrected bytes are automatically checked to be sure the correction is done properly.

Not all errors are correctable. Error correction circuits can correct almost any combination of errors as long as they all occur in the same track within a nine-track block. If a block contains errors in more than one track, they cannot be corrected. The key to error correction is determination of which track contains the errors. Once the track in error has been located, actual correction becomes a simple matter.

CYCLIC REDUNDANCY CHECK REGISTER

As each character passes through the R/W (read or write) register, it is shifted in parallel into the cyclic redundancy check register (CRCR). The CRCR consists of nine binary triggers and their associated circuits. Positions are designated P, 0 through 7. Characters are shifted into the CRCR from the read/write (R/W) register to develop a cyclic redundancy check character. Output of the CRCR returns to the R/W register. In the following chart, inputs on the left are exclusive OR'ed with the present status of the CRCR positions will be changed at shift pulse time. In the case of CRC register positions P, 0, 1, 6, and 7, any one and only one of the two conditions active (input and two CRCR positions) will set the corresponding trigger to the "one" state. This is accomplished by first exclusive OR'ing two of the three conditions and then exclusive OR'ing that result with the third condition.

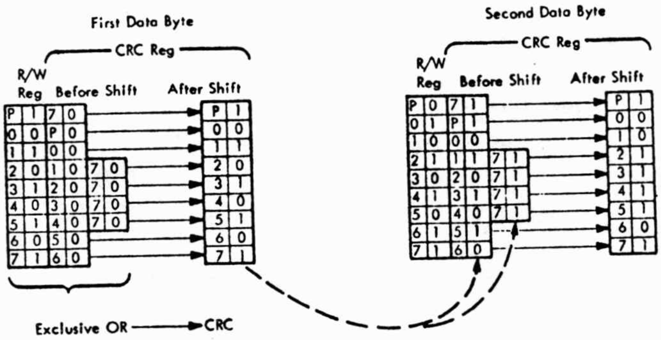
READ/WRITE REGISTER INPUTS		OE	CRCR POSITION		CRCR CHANGED
READ BACKWARD	WRITE AND READ FORWARD				
7	P	OE 7		=	P
6	0	OE P		=	0
5	1	OE 0		=	1
4	2	OE 1	OE 7	=	2
3	3	OE 2	OE 7	=	3
2	4	OE 3	OE 7	=	4
1	5	OE 4	OE 7	=	5
0	6	OE 5		=	6
P	7	OE 6		=	7

WRITE

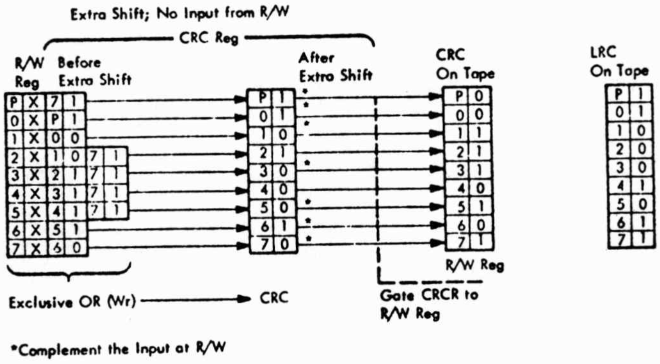
During write, each character is shifted in parallel from the R/W register into the CRCR. Because of the shift pattern of the CRCR, a check character is developed which can be written on tape at the end of the record. After all the data bytes have been shifted into the CRCR, one more shift pulse is generated with no inputs. The extra shift at the end of a write operation will make the total number of shifts equal to the total number of data bytes plus one additional shift. The CRCR character (first check character) is written four character spaces after the data and four character spaces before the LRC character (second check character).

The CRC character written on tape is not the same bit configuration as the contents of the CRC register. CRCR bit positions are complemented (except 2 and 4) as they are written. If the CRCR has all positions on (111 111 111), the CRC character written on tape will be 000 101 000.

The following is an example of CRC register operation during write. In this example two data bytes are written on tape and the CRC character is computed and written on the tape. Data bytes used in this example are 101 010 101 and 010 101 011:



Notice that the first data byte enters the CRC register without change. The second byte is modified because the CRCR contains the first data character at the time of the second shift. During write the CRCR is shifted one extra time with no inputs, to produce the following result:



The CRC character written on tape will be 001 110 101. The LRC character will be 110 001 011. The LRC character will be 110 001 011. Notice that the CRC character contains odd parity. The shifting pattern of the CRC register always results in an odd parity CRC character when the block contains an even number of bytes. An even parity CRC character will result from a block with an odd number of bytes.

In nine-track operation the LRC character will always be odd. The pattern of bits in the CRC character assures that every LRC character will have odd parity.

READ FORWARD

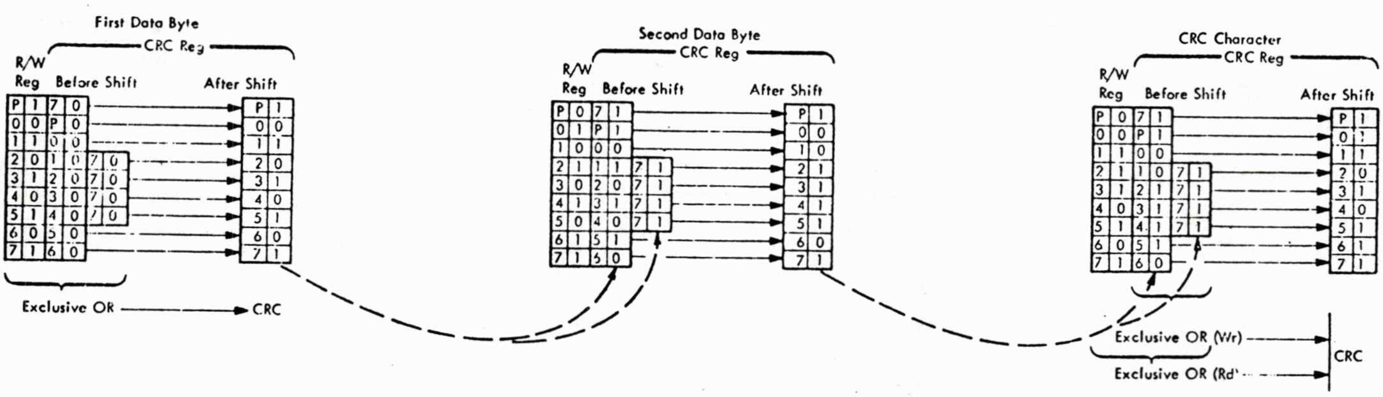
During read operation, the CRCR calculates a check character from the R/W register data (as in a write operation). Each character including the CRCC is shifted into the CRCR from the R/W register. The total number of shifts is equal to the number of data characters read plus one for the CRC character read from tape.

If no errors have occurred, the CRCR should contain a "match pattern." The match pattern is 111 010 111.

The following example illustrates CRCR operation during a read command with no data errors. Data used in this example is the same two byte block used in the write preceding operation example:

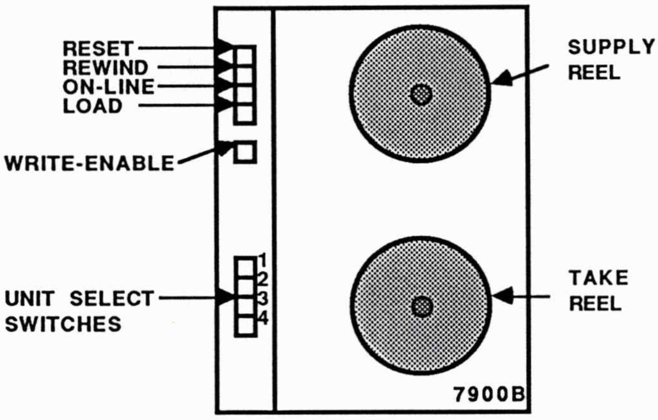
1st data byte	101 010 101
2nd data byte	010 101 011
CRC character	001 110 101
LRC character	110 001 011

The first and second data bytes produce the same CRCR bit pattern that was produced during the two data cycles of the write operation. When the CRC character is shifted into the CRC register a match patter (111 010 111) is produced.



7970B MAGNETIC TAPE SUBSYSTEM

28071A



READ CONTROL

MTTRD (IUNIT,FPVAR,NI,IEOF,NT)

IUNIT = MAGNETIC TAPE UNIT NUMBER (0 - 3)
FPVAR = FIRST VARIABLE OF REAL ARRAY TO BE TRANSFERRED.
NI = NUMBER OF VARIABLES TO BE TARNSFERRED.
IEOF = END OF FILE FLAG RETURNED BY THE DRIVER:

0 = NO END OF FILE READ
1 = END OF FILE READ

NT = ACTUAL NUMBER OF VARIABLES TRANSFERRED.

WRITE CONTROL

MTTRT (IUNIT,FPVAR,NI,IEOF,NT)

VARIABLES SAME AS ABOVE . IEOF IS ALWAYS SET TO 0 BY A WRITE OPERATION.

AVTAR

7970B MAGNETIC TAPE SUBSYSTEM

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POSITION CONTROL

MTTPT (IUNIT,IF,IR)

IF = FILE SPACING
+ IF = FORWARD " F " FILES
- IF = BACKWARD " F " FILES
IR = RECORD SPACING
+IR = FORWARD " R " RECORDS
-IR = BACKWARD " R " RECORDS

AT THE END OF READ/WRITE OPERATION, THE TAPE IS POSITIONED AT THE BEGINNING FO NEXT RECORDS; IF IT IS DESIRED TO READ A RECORD AFTER WRITING, THE CALL (IUINT,0,-1) SHOULD BE USED. A BACKFILE COMMAND LEAVES THE TAPE POSITIONED ON THE SIDE OF THE FILE MARK AWAY FROM THE LOAD POINT.

FUNCTION CONTROL

MTTSF (IUNIT,FUNC)

FULNC = FUNCTION

0 = WRITE 4" GAP
1 = WRITE EOF AND 4" GAP
2 = REWIND TAPE
3 = REWIND TAPE AND PUT ON LOCAL
(REWIND AND STANDBY)

ERROR CONDITIONS

1 = CALL PARAMAETE ERROR
2 = TIMING ERROR
3 = EOT/BOT
4 = PARITY ERROR
(AFTER THREE ATTEMPTS)
5 = TAPE DRIVE IN LOCAL
6 = WRITE NOT ENABLED
7 = WRITE DMA TRANSFER ERROR
9 = READ DMA TRANSFER ERROR
10 = NO FLAG FROM COMMAND CHN. AFTER WRITE.
11 = NO FLAG FROM COMMAND CH.. AFTER READ.
DST-1= INVALID VARIABLE

AVTAR